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(71) Applicant:	ELI LILLY AND COMPANY [US/US]; Lilly Corporate Center, Indianapolis, IN 46285 (US).		
(72) Inventors:	HEATH, William, Francis, Heath, Jr.; 11214 Tufton Street, Fishers, IN 46038 (US). MCDONALD, John, Hampton, III; 433 Portsmouth Court, Carmel, IN 46032 (US). PAAL, Michael; Hummelsbuttel Kirchenweg 11, D-22335 Hamburg (DE). RÜTHER, Gerd; Vierzigstücken 53, D-21129 Hamburg (DE). SCHOTTEN, Theo; Hintern Bach 34, D-21444 Vierhufen (DE). STENZEL, Wolfgang; Lerchenweg 8, D-21465 Reinbek (US).		
(74) Agents:	LAMMERT, Steven, R. et al.; Barnes & Thornburg, 1313 Merchants Bank Building, 11 South Meridian Street, Indianapolis, IN 46204 (US).		

(54) Title: PROTEIN KINASE C INHIBITORS

(57) Abstract

The present invention discloses compounds that are highly isozyme selective protein kinase C beta-1 and beta-2 isozyme inhibitors. Accordingly, the present invention provides a method of selectively inhibiting protein kinase C isozymes beta-1, and beta-2. As isozyme selective inhibitors of beta-1 and beta-2, the compounds are therapeutically useful in treating conditions associated with diabetes mellitus and its complications, as well as other disease states associated with an elevation of the beta-1 and beta-2 isozymes.

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PROTEIN KINASE C INHIBITORS

Protein kinase C (PKC) consists of a family of closely related enzymes that function as serine/threonine kinases. Protein kinase C plays an important role in cell-cell signaling, gene expression, and in the control of cell differentiation and growth. At present, there are currently at least ten known isozymes of PKC that differ in their tissue distribution, enzymatic specificity, and regulation. Nishizuka Y. Annu. Rev. Biochem. **58**: 31-44 (1989); Nishizuka Y. Science **258**: 607-614 (1992).

Protein kinase C isozymes are single polypeptide chains ranging from 592 to 737 amino acids in length. The isozymes contain a regulatory domain and a catalytic domain connected by a linker peptide. The regulatory and catalytic domains can be further subdivided into constant and variable regions. The catalytic domain of protein kinase C is very similar to that seen in other protein kinases while the regulatory domain is unique to the PKC isozymes. The PKC isozymes demonstrate between 40-80% homology at the amino acid level among the group, however, the homology of a single isozyme between different species is generally greater than 97%.

Protein kinase C is a membrane-associated enzyme that is allosterically regulated by a number of factors, including membrane phospholipids, calcium, and certain membrane lipids such as diacylglycerols that are liberated in response to the activities of phospholipases. Bell, R.M. and Burns, D.J., J. Biol. Chem. **266**: 4661-4664 (1991); Nishizuka, Y. Science **258**: 607-614 (1992). The protein kinase C isozymes, alpha, beta-1, beta-2 and gamma, require membrane phospholipid, calcium and diacylglycerol/phorbol esters for full activation. The delta, epsilon, eta, and theta forms of PKC are calcium-independent in their mode of

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activation. The zeta and lambda forms of PKC are independent of both calcium and diacylglycerol and are believed to require only membrane phospholipid for their activation.

5 Only one or two of the protein kinase C isozymes may be involved in a given disease state. For example, the elevated blood glucose levels found in diabetes lead to an isozyme-specific elevation of the beta-2 isozyme in vascular tissues. Inoguchi et al., Proc. Natl. Acad. Sci. USA **89**: 11059-11065 (1992). A diabetes-linked elevation of the beta isozyme in human platelets has been correlated with their altered response to agonists. Bastyr III, E.J. and Lu, J. Diabetes **42**: (Suppl 1) 97A (1993). The human vitamin D receptor has been shown to be selectively 15 phosphorylated by protein kinase C beta. This phosphorylation has been linked to alterations in the functioning of the receptor. Hsieh et al., Proc. Natl. Acad. Sci. USA **88**: 9315-9319 (1991); Hsieh et al., J. Biol. Chem. **268**: 15118-15126 (1993). In addition, recent work 20 has shown that the beta-2 isozyme is responsible for erythroleukemia cell proliferation while the alpha isozyme is involved in megakaryocyte differentiation in these same cells. Murray et al., J. Biol. Chem. **268**: 15847-15853 (1993).

25 The ubiquitous nature of the protein kinase C isozymes and their important roles in physiology provide incentives to produce highly isozyme selective PKC inhibitors. Given the evidence demonstrating linkage of certain isozymes to disease states, it is reasonable to 30 assume that inhibitory compounds that are selective to one or two protein kinase C isozymes relative to the other PKC isozymes are superior therapeutic agents. Such compounds should demonstrate greater efficacy and lower toxicity by virtue of their specificity.

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Compounds are known to be protein kinase C inhibitors. Some are also known to demonstrate specificity to protein kinase C. However, very little is known regarding isozyme selectivity. Studies of the 5 PKC-selective compound, 3-[1-(3-dimethylaminopropyl)-indol-3-yl]-4-(1H-indol-3-yl)-1H-pyrrole-2,5-dione, suggest a slight selectivity for the calcium dependent isozymes, but find no isozyme selectivity between alpha, beta-1, beta-2, and gamma. Toullec et al., J. Biol. Chem. 266: 10 15771-15781 (1991). Martiny-Baron, et al., J. Biol. Chem. 268: 9194-9197 (1993), tested the same compound and found slight selectivity for isozymes, alpha and beta versus delta, epsilon, and zeta. Martiny-Baron observed no differences in the selectivity between alpha and beta-1 15 isozymes. Wilkinson, et al., Biochem. J. 294: 335-337 (1993), failed to observe any high degree of isozyme selectivity and suggest only slight selectivity for the alpha isozyme and equal inhibition of beta, gamma, and epsilon for several species of bis-indolemaleimides. 20 Therefore, despite years of research, there remains a need for therapeutically effective isozyme-selective inhibitors.

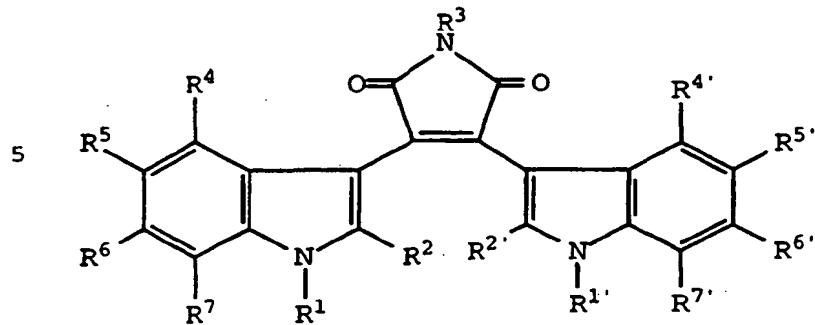
This invention provides the unexpected discovery that the compounds of the present invention are highly isozyme selective. The compounds selectively inhibit 25 protein kinase C beta-1 and beta-2 isozymes. Accordingly, the present invention provides a method of selectively inhibiting protein kinase C isozymes beta-1 and beta-2. As isozyme selective inhibitors of beta-1 and beta-2, the compounds are therapeutically useful in treating conditions 30 associated with diabetes mellitus and its complications, as well as other disease states associated with an elevation of the beta-1 and beta-2 isozymes.

This invention provides a method of selectively

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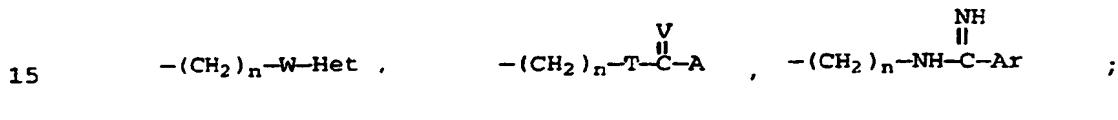
inhibiting protein kinase C beta-1 and beta-2 isozyme, which comprises administering to a mammal in need of such treatment a pharmaceutically effective amount of a compound of the Formula I:



(I)

wherein:

10 R^1 and $R^{1'}$ are independently hydrogen, alkyl, haloalkyl, alkenyl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, monoalkylaminoalkyl, dialkylaminoalkyl, acylaminoalkyl, acyloxyalkyl, cyanoalkyl, amidinoalkyl, carboxyalkyl, alkoxy carbonylalkyl, aminocarbonylalkyl, or a group of the formula:



(a)

(b)

(c)

Het signifies a heterocyclyl group;

W signifies NH, S or a bond;

T signifies NH or S;

20 V signifies O, S, NH, or NCN;

A signifies alkylthio, amino, monoalkylamino or

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dialkylamino;

Ar signifies aryl;

R² and R²' are independently hydrogen, alkyl, alkoxyalkyl, hydroxyalkyl, C₁-C₃ alkylthio, S(0)C₁-C₃ alkyl, 5 CF₃; or R¹ and R² can combine to form -(CH₂)_r-X-CH₂-; R³ is hydrogen or CH₃CO;

R⁴, R⁴', R⁵, R⁵', R⁶, R⁶', R⁷ and R⁷' are independently hydrogen, halogen, alkyl, hydroxy, alkoxy, -COO(C₁-C₃ alkyl), CF₃, nitro, amino, acetylamino, 10 monoalkylamino, dialkylamino, alkylthio, C₁-C₃ alkylthio, or S(0)C₁-C₃ alkyl;

X is CHR⁸ or NR⁸;

R⁸ is (CH₂)_sR⁹;

R⁹ is hydrogen, hydroxy, alkoxy, amino, 15 monoalkylamino, dialkylamino, trialkylamino, azido, acylamino, alkoxy carbonyl, cyano, amidino, or aminocarbonyl;

n is 1, 2, 3, 4, 5 or 6;

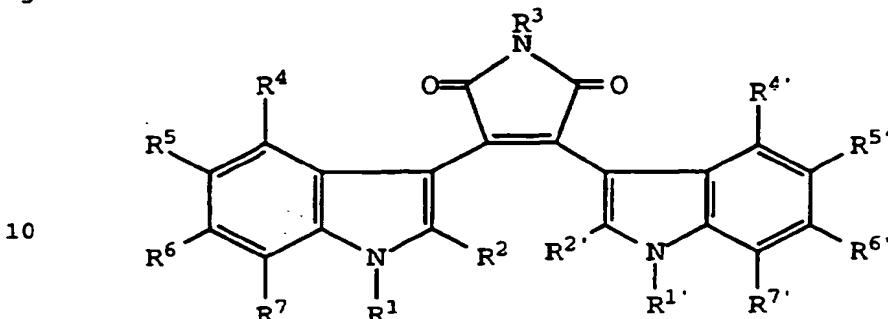
r is 1, 2, or 3; and

20 s is 0, 1, 2 or 3.

As selective inhibitors, the invention further provides a method for treating diabetes mellitus, which comprises administering to a mammal in need of such 25 treatment a pharmaceutically effective amount of a compound of the Formula I.

In addition, the present invention provides novel compounds, which are isozyme selective PKC inhibitors, of the Formulas II, III, and IV:

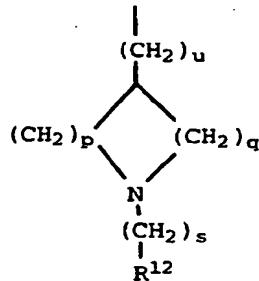
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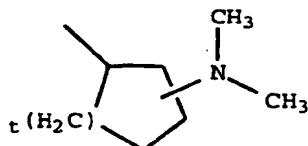
(II)

15 wherein:

20

R¹ is

(d)



(e)

or

(f)

25

R¹' is hydrogen, C₁-C₄ alkyl, aminoalkyl, monoalkylaminoalkyl, or dialkylaminoalkyl;

R² and R²' are independently hydrogen, alkyl, alkoxyalkyl, hydroxyalkyl, C₁-C₃ alkylthio, S(0)C₁-C₃ alkyl, CF₃;

30

R³ is hydrogen or CH₃CO-;

R⁴, R⁴', R⁵, R⁵', R⁶, R⁶', R⁷ and R⁷' are independently hydrogen, halogen, alkyl, hydroxy, alkoxy, -COO(C₁-C₃ alkyl), CF₃, nitro, amino, acetylamino, monoalkylamino, dialkylamino, alkylthio, C₁-C₃ alkylthio,

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or $S(O)C_1-C_3$ alkyl;

R^{12} is hydrogen, alkyl, haloalkyl, cycloalkyl, acetyl, aryl, $-CH(aryl)_2$, amino, monoalkylamino, dialkylamino, guanidino, $-C(=N(alkoxycarbonyl))NH$

5 (alkyoxy carbonyl), amidino, hydroxy, carboxy, alkoxy carbonyl or heterocyclyl;

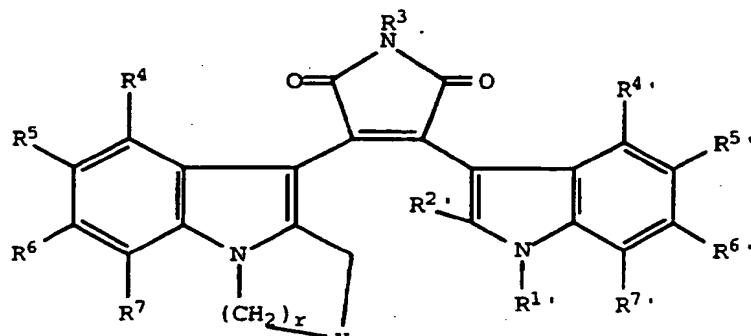
p and q are independently 1, 2, 3, or 4;

s is 0, 1, 2 or 3;

t is 1 or 2;

10 u is 0 or 1; or

pharmaceutically acceptable salts or solvates thereof.



wherein:

15 R^1' is hydrogen, C_1-C_4 alkyl, aminoalkyl, monoalkylaminoalkyl, or dialkylaminoalkyl;

R^2' is hydrogen, alkyl, alkoxyalkyl, hydroxyalkyl, C_1-C_3 alkylthio, $S(O)C_1-C_3$ alkyl, CF_3 ;

R^3 is hydrogen or CH_3CO- ;

20 R^4 , R^4' , R^5 , R^5' , R^6 , R^6' , R^7 and R^7' are

independently hydrogen, halogen, alkyl, hydroxy, alkoxy, $-COO(C_1-C_3$ alkyl), CF_3 , nitro, amino, acetyl amino, monoalkylamino, dialkylamino, alkylthio, C_1-C_3 alkylthio, or $S(O)C_1-C_3$ alkyl;

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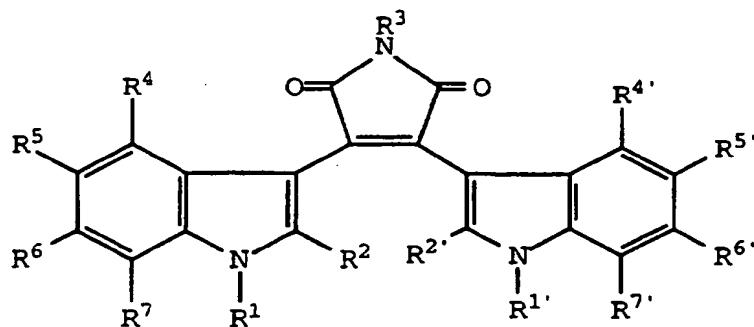
X is CR⁸R⁹;R⁸ is (CH₂)_sR¹⁰;R⁹ is (CH₂)_sR¹¹;R¹⁰ and R¹¹ are independently hydroxy, alkoxy,

5 carboxy, acyloxy, amino, monoalkylamino, dialkylamino, trialkylamino, azido, acylamino, alkoxy carbonyl, cyano, amidino, or aminocarbonyl;

r is 1, 2, or 3;

s is 0, 1, 2 or 3; or

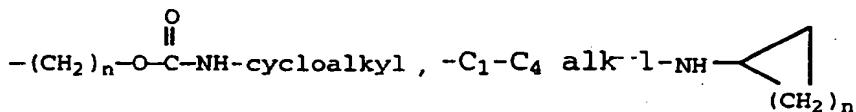
10 pharmaceutically acceptable salts or solvates thereof.



(IV)

wherein:

15



20 R¹ is or
alkylglycose residue;
R^{1'} is hydrogen, C₁-C₄ alkyl, cyclopropylmethyl, aminoalkyl, monoalkylaminoalkyl, or dialkylaminoalkyl;
R² and R^{2'} are independently hydrogen, alkyl,
25 alkoxyalkyl, hydroxyalkyl, C₁-C₃ alkylthio, S(0)C₁-C₃ alkyl,

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CF₃;R³ is hydrogen or CH₃CO-;

R⁴, R^{4'}, R⁵, R^{5'}, R⁶, R^{6'}, R⁷ and R^{7'} are independently hydrogen, halogen, alkyl, hydroxy, alkoxy, -COO(C₁-C₃ alkyl), CF₃, nitro, amino, acetylamino, monoalkylamino, dialkylamino, alkylthio, C₁-C₃ alkylthio, or S(0)C₁-C₃ alkyl;

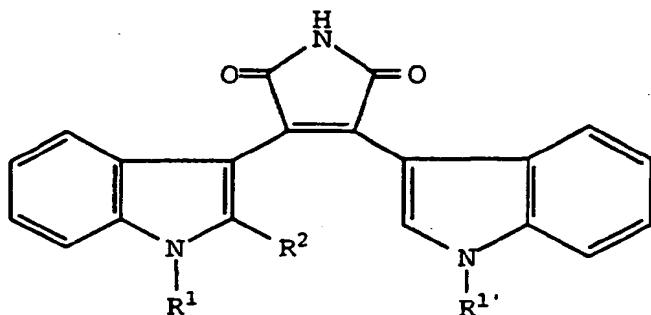
n is 1, 2, 3, 4, 5 or 6; or pharmaceutically acceptable salts or solvates thereof.

10

As noted above, the invention provides compounds of the Formula I which selectively inhibit isozymes of protein kinase C.

The preferred compounds of this invention are those 15 compounds of the Formula Ia and Ib:

20



(Ia)

25

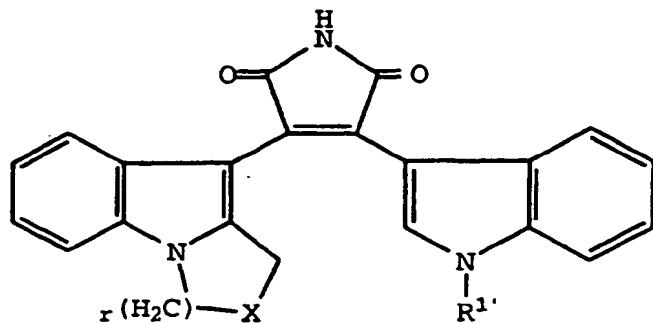
wherein: R¹ is hydrogen, aminoalkyl, monoalkylaminoalkyl, dialkylaminoalkyl;

R^{1'} is hydrogen, C₁-C₄ alkyl, aminoalkyl, monoalkylaminoalkyl, or dialkylaminoalkyl; and

30

R² is hydrogen or methyl.

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(Ib)

5 R^{1'} is hydrogen or C₁-C₄ alkyl;

 X is CR⁸R⁹ or NR⁸;

 R⁸ is (CH₂)_sR¹⁰;

 R⁹ is (CH₂)_sR¹¹;

 R¹⁰ and R¹¹ are independently hydrogen, hydroxy, amino, monoalkylamino, or dialkylamino;

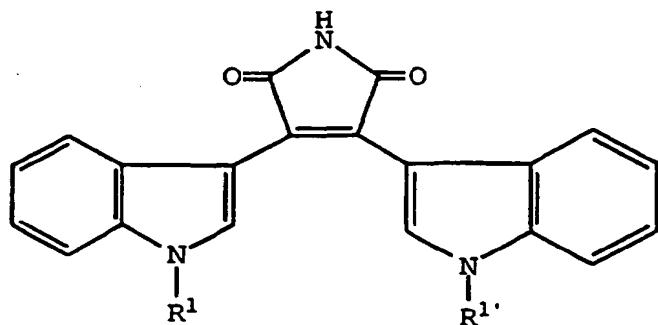
 r is 1 or 2; and

 s is 1.

10

 As previously noted, some of the compounds of the present invention are novel. The preferred novel compounds of the present invention are compounds of the Formula II wherein u is 0. The most preferred novel compounds of Formula II are of the Formula (IIa):

20

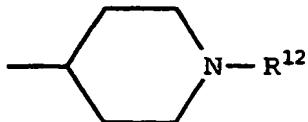


(IIa)

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5

wherein: R¹ isR¹' is hydrogen, or C₁-C₄ alkyl; and10 R¹² is hydrogen, or C₁-C₄ alkyl.

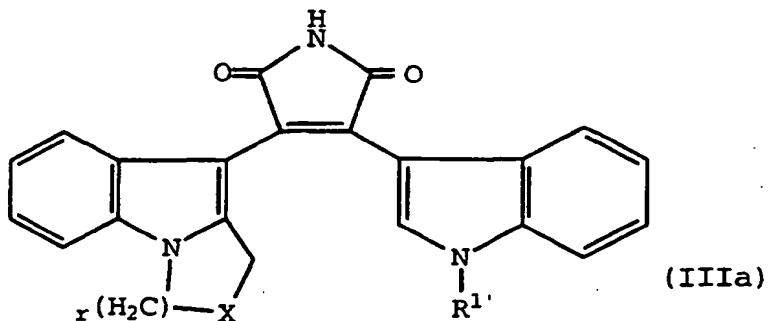
Other preferred novel compounds of the present invention are compounds of the Formula IIIa:

15

20

25

30



wherein

R¹' is hydrogen, alkyl, aminoalkyl, monoalkylaminoalkyl, or dialkylaminoalkyl;35 X is CR⁸R⁹;R⁸ is (CH₂)_sR¹⁰;R⁹ is (CH₂)_sR¹¹;R¹⁰ and R¹¹ are independently hydroxy, carboxy, alkoxy carbonyl, amino, monoalkylamino, or dialkylamino;

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r is 1 or 2; and
s is 0 or 1.

As used herein, the term "alkyl", alone or in
5 combinations, means a straight or branched-chain alkyl
group containing from one to seven, preferably one to four,
carbon atoms such as methyl, ethyl, propyl, isopropyl,
butyl, sec-butyl, t-butyl and pentyl. The term "C₁-C₄
alkyl" is an alkyl limited to one to four carbon atoms.

10 The term "cycloalkyl", alone or in combinations,
means a three to seven carbon cycloalkyl, for example,
cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, and
cycloheptyl.

15 The term "alkenyl" means a two to seven carbon,
straight or branched hydrocarbon containing one or more
double bonds, preferably one or two double bonds. Examples
of alkenyl include ethylene, propylene, 1,3 butadienyl,
and 1,3,5-hexatrienyl.

20 The term "alkoxy", alone or in combinations, is an
alkyl covalently bonded by an -O- linkage. Examples of
alkoxy groups are methoxy, ethoxy, propoxy, isopropoxy,
butoxy and t-butoxy. An alkoxyalkyl is, for example,
CH₃(CH₂)-O-(CH₂)_m- wherein m is the from one to seven or
preferably one to four. The term alkoxy carbonyl is, for
25 example, t-butoxycarbonyl or BOC.

A haloalkyl group is an alkyl with one or more,
preferably one to three halogen atoms, examples of such
group CH₂Cl, CF₃, CH₂CF₃, CH₂(CF₂)₂CF₃, and the like.

30 The acyl moiety of an acylamino or acylaminoalkyl
group is derived from an alkanoic acid containing a maximum
of 7, preferably a maximum of 4, carbon atoms (e.g. acetyl,
propionyl or butyryl) or from an aromatic carboxylic acid
(e.g. benzoyl). An acyloxy is one such acyl bonded by an
-O- linkage, for example, acyloxy, CH₃C(=O)O-. An

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acylamino is, for example, $\text{CH}_3(\text{C}=\text{O})\text{NH}-$ (acetylamino).

Likewise, an acylaminoalkyl is $\text{CH}_3(\text{C}=\text{O})\text{NH}(\text{CH}_2)_m-$.

The term "aryl", alone or in combinations means an unsubstituted phenyl group or a phenyl group carrying one or more, preferably one to three, substituents.

5 independently selected from halogen, alkyl, hydroxy, benzyloxy, alkoxy, haloalkyl, nitro, amino, acylamino, monoalkylamino, dialkylamino, alkylthio, alkylsulfinyl, alkylsulfonyl and cyano. The term arylalkyl is preferably 10 benzyl.

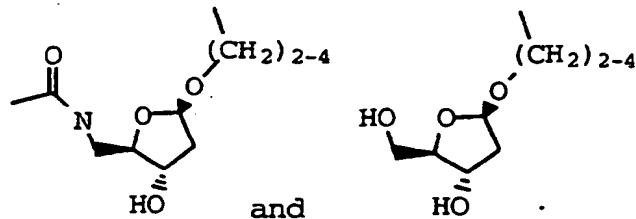
The term "halogen" means fluorine, chlorine, bromine or iodine.

The heterocyclic group denoted by "Het" or "heterocyclyl" can be a stable, saturated, partially 15 unsaturated, or aromatic 5- or 6-membered heterocyclic group. The heterocyclic ring consists of carbon atoms and from one to three heteroatoms independently selected from the group consisting of nitrogen, oxygen, and sulfur. The heterocyclic group can be optionally substituted with one 20 to three substituents independently selected from halogen, alkyl, hydroxy, alkoxy, haloalkyl, nitro, amino, acylamino, monoalkylamino, dialkylamino, alkylthio, alkylsulfinyl and alkylsulfonyl or, when the heterocyclyl group is an aromatic nitrogen-containing heterocyclic group, the 25 nitrogen atom can carry an oxide group. Examples of such heterocyclyl groups are imidazolyl, imidazolinyl, thiazolinyl, pyridyl, indolyl, furyl, and pyrimidinyl.

The term "alkylglycose residue" represents a 30 glycose moiety linked in the C-1 position to the indolyl via a C₂-C₄ alkyl. Glycoses included in alkylglycose residue are natural or unnatural 5 or 6 carbon sugars, preferably selected from allosyl, altrosyl, glucosyl, mannosyl, gulosyl, idosyl, galactosyl, talosyl, arabinosyl, xylosyl, lyxosyl, rhamnosyl, ribosyl, deoxyfuranosyl,

deoxypyranosyl, and deoxyribosyl. The glycose may be azide substituted, O-acetylated, O-methylated, amino, mono, and di-alkylamino substituted, or acylamino substituted. For example, alkylglycose residue includes:

5



The term "pharmaceutically effective amount", as used herein, represents an amount of a compound of the 10 invention that is capable of selectively inhibiting PKC isozyme activity in mammals. The particular dose of the compound administered according to this invention will, of course, be determined by a physician under the particular circumstances surrounding the case, including the compound 15 administered, the route of administration, the particular condition being treated, and similar considerations. The compounds can be administered by a variety of routes including the oral, rectal, transdermal, subcutaneous, topical, intravenous, intramuscular or intranasal routes.

20 The term "treating," as used herein, describes the management and care of a patient for the purpose of combating the disease, condition, or disorder and includes the administration of a compound of present invention to prevent the onset of the symptoms or complications, 25 alleviating the symptoms or complications, or eliminating the disease, condition, or disorder.

The term "isozyme selective" means the preferential inhibition of protein kinase C beta-1 or beta-2 isozymes over protein kinase C isozymes, alpha, gamma, delta,

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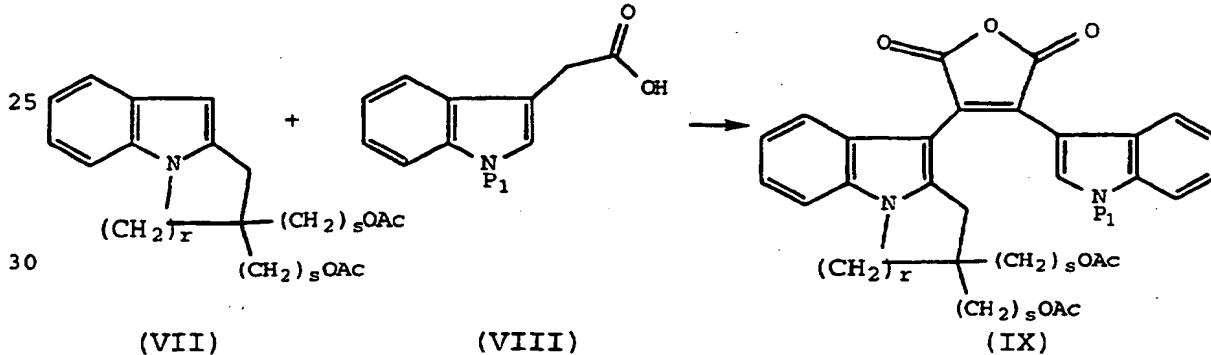
epsilon, zeta, and eta. In general, the compounds demonstrate a minimum of a eight fold differential, preferably ten fold differential, in the dosage required to inhibit PKC beta-1 or beta-2 isozymes and the dosage required for equal inhibition of the alpha protein kinase C isozyme as measured in the PKC assay. The compounds demonstrate this differential across the range of inhibition and are exemplified at the IC₅₀, i.e., a 50% inhibition. Accordingly, the invention provides a method for selectively inhibiting the beta-1 or beta-2 protein kinase C isozyme. A related phrase is "selectively inhibiting protein kinase C beta-1 and beta-2 isozymes," which refers to isozyme selective inhibition. Thus, because one needs a substantially higher concentration of compound to inhibit the other protein kinase C isozymes (e.g., Example 11 discloses 50% inhibition at a concentration of 0.046 μmol/L for the beta-2 protein kinase C isozyme while the IC₅₀ with respect to the alpha protein kinase C isozyme is 0.45 μmol/L), a pharmaceutically effective dosage of the compound inhibits beta-1 and beta-2 protein kinase C isozymes with lower toxicity by virtue of their minimal inhibition of the other isozymes.

The synthesis of the compounds is described in Davis et al. U.S. Patent 5,057,614, herein incorporated by reference. The novel compounds of Formulas II, III, and IV are readily prepared in an analogous process to that disclosed in U.S. Patent 5,057,614 and known in the art as evidenced by EPO 397 060 (1990) and Bit et al., J. Med. Chem. 36: 21-29 (1993). For example, when preparing the novel compounds of Formula II, III, or IV, the alkylation of the indole nitrogen occurs under conditions appreciated in the art. The reaction usually involves approximately equimolar amounts of the two reagents, although other ratios, especially those wherein the alkylating reagent is

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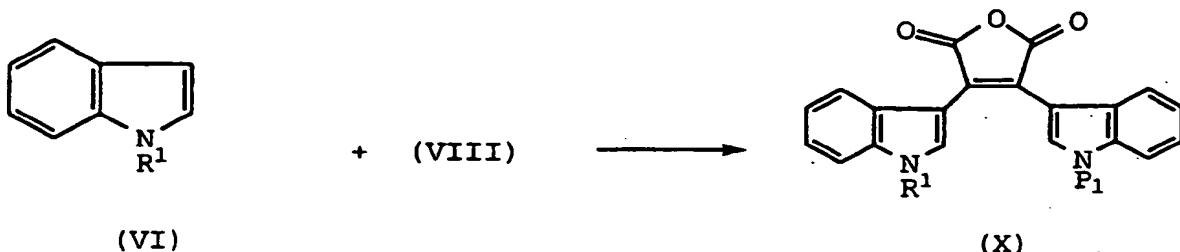
in excess, are operative. The reaction is best carried out in a polar aprotic solvent employing an alkali metal salt or other such alkylation conditions as are appreciated in the art. When the leaving group is bromo or chloro, a 5 catalytic amount of iodide salt, such as potassium iodide may be added to speed the reaction. Preferred reaction conditions include the following: Potassium hexamethyldisilazide in dimethylformamide or tetrahydrofuran, sodium hydride in dimethylformamide, or cesium carbonate in acetonitrile. The temperature of the 10 reaction is preferably from about ambient temperature to about the reflux temperature of the reaction mixture. When elevated temperatures are employed, the reaction is generally complete in 1-4 hours.

15 The novel compounds of Formula II, III, and IV can
be prepared by procedures described in Chem. Pharm. Bull.,
33(5) 1826-1835 (1985), Synth. Commun., 18(3) 265-273
(1988) and J. Org. Chem., 44(4) 578-586 (1979) and are
generally described in Scheme 1.



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In the above scheme, r, s, and R¹ are the same as previously defined in Formula II, III, or IV; and Ac is acetyl. P₁ is a protecting group such as t-butoxycarbonyl or other indole protecting group known in the art. T. W. Greene and P. Wuts, Protective Groups in Organic Synthesis, Chapter 7, page 385. The reaction described in Scheme 1 is known as a Perkin Condensation. The reaction is described in Hill et al., J. Med. Chem. 36: 21-29 (1993). Generally, oxalyl chloride is added at between -78°C and the reflux temperature of the mixture (preferably at 0°C) to an anhydrous solution of Compound VI or VII in inert organic solvent such as a halogenated hydrocarbon like methylene chloride. The volatiles are then removed. The resulting solids are dissolved in a dry halogenated hydrocarbon solvent, e.g. methylene chloride; and added to Compound VIII in the presence of a base, preferably a tertiary amine such as triethylamine, at room temperature.

The acetyloxy alkyl (OAc) of Compound IX may be converted to an alcohol by reacting Compound IX with NH₄OH or aqueous ammonia in DMF at elevated temperatures, e.g. 140°C. The resulting alcohol may be converted to the amine or the other substitutions of Formula III by methods known in the art. For example, the alcohol in dichloromethane and collidine under a nitrogen atmosphere may be reacted with triflic anhydride in dichloromethane. After

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approximately two hours, the mixture is treated with aqueous ammonia to form the amine.

5 The conversion of the anhydride of Compound IX or X to the maleimides of Formula I, II, III, or IV occurs by an ammonolysis as described in Brenner et al., Tetrahedron 44: 2887-2892 (1988). For example, the anhydride may be converted to the bis-indole maleimide by reacting the anhydride with hexamethyldisilazane and methanol in an inert organic solvent such as DMF at room temperature.

10 Compounds VI, VII, VIII, and any other reagents required for the reactions described herein, are either commercially available, known in the art, or can be prepared by methods known in the art. For example, Compound VI may be prepared by techniques described in M. 15 Adachi et al., Chem. Pharm. Bull., 33(5), 1826-35 (1985); K. Sasakura et al., Synth. Commun., 18(3), 265-273 (1988).

20 By virtue of their acidic moieties, the compounds of Formulas II, III, or IV include the pharmaceutically acceptable base addition salts thereof. Such salts include those derived from inorganic bases such as ammonium and alkali and alkaline earth metal hydroxides, carbonates, bicarbonates, and the like, as well as salts derived from basic organic amines such as aliphatic and aromatic amines, aliphatic diamines, hydroxy alkamines, and the like. Such 25 bases useful in preparing the salts of this invention thus include ammonium hydroxide, potassium carbonate, sodium bicarbonate, calcium hydroxide, methylamine, diethylamine, ethylenediamine, cyclohexylamine ethanolamine and the like.

30 Because of the basic moiety, the compounds of Formulas II, III, or IV can also exist as pharmaceutically acceptable acid addition salts. Acids commonly employed to form such salts include inorganic acids such as hydrochloric, hydrobromic, hydroiodic, sulfuric and phosphoric acid, as well as organic acids such as

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para-toluenesulfonic, methanesulfonic, oxalic, para-bromophenylsulfonic, carbonic, succinic, citric, benzoic, acetic acid, and related inorganic and organic acids. Such pharmaceutically acceptable salts thus include sulfate, 5 pyrosulfate, bisulfate, sulfite, bisulfite, phosphate, monohydrogenphosphate, dihydrogenphosphate, metaphosphate, pyrophosphate, chloride, bromide, iodide, acetate, propionate, decanoate, caprylate, acrylate, formate, isobutyrate, caproate, heptanoate, propiolate, oxalate, 10 malonate, succinate, suberate, sebacate, fumarate, maleate, 2-butyn-1,4 dioate, 3-hexyn-2, 5-dioate, benzoate, chlorobenzoate, hydroxybenzoate, methoxybenzoate, phthalate, xylenesulfonate, phenylacetate, phenylpropionate, phenylbutyrate, citrate, lactate, 15 hippurate, β -hydroxybutyrate, glycollate, maleate, tartrate, methanesulfonate, propanesulfonate, naphthalene-1-sulfonate, naphthalene-2-sulfonate, mandelate and the like salts.

In addition to pharmaceutically-acceptable salts, 20 other salts are included in the invention. They may serve as intermediates in the purification of compounds or in the preparation of other salts, or are useful for the identification, characterization or purification.

The pharmaceutically acceptable salts of compounds 25 of Formulas II, III, or IV can also exist as various solvates, such as with water, methanol, ethanol, dimethylformamide, ethyl acetate and the like. Mixtures of such solvates can also be prepared. The source of such solvate can be from the solvent of crystallization, 30 inherent in the solvent of preparation or crystallization, or adventitious to such solvent. Such solvates are within the scope of the present invention.

It is recognized that various stereoisomeric forms of the compounds of Formulas II, III, or IV may exist; for

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example, in Formula III, X introduces a chiral carbon atom. The compounds are normally prepared as racemates and can conveniently be used as such, but individual enantiomers can be isolated or synthesized by conventional techniques 5 if so desired. Such racemates and individual enantiomers and mixtures thereof form part of the present invention.

The invention also encompasses the pharmaceutically acceptable prodrugs of the compounds of Formula I, II, III and IV. A prodrug is a drug which has been chemically 10 modified and may be biologically inactive at its site of action, but which may be degraded or modified by one or more enzymatic or other in vivo processes to the parent bioactive form. This prodrug should have a different pharmacokinetic profile than the parent, enabling easier 15 absorption across the mucosal epithelium, better salt formation or solubility, and/or improved systemic stability (an increase in plasma half-life, for example). Typically, such chemical modifications include the following:

1) ester or amide derivatives which may be cleaved 20 by esterases or lipases;

2) peptides which may be recognized by specific or nonspecific proteases; or

25 3) derivatives that accumulate at a site of action through membrane selection of a prodrug form or a modified prodrug form; or any combination of 1 to 3, supra.

Conventional procedures for the selection and preparation of suitable prodrug derivatives are described, for example, 30 in H. Bundgaard, Design of Prodrugs, (1985).

As previously noted, the compounds of the present invention are potent, beta-1 and beta-2 isozyme selective PKC inhibitors. As such, they are useful in the treatment of conditions associated with diabetes mellitus and its complications, as well as other disease states associated with an elevation of PKC and, in particular, the beta-1 and

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beta-2 isozymes.

Protein kinase C beta-1 and beta-2 has been linked to diabetes. Inoguchi et al., Proc. Natl. Acad. Sci. USA 89: 11059-11065 (1992). In addition, excessive activity of 5 protein kinase C has been linked to insulin signaling defects and therefore to the insulin resistance seen in Type II diabetes. Karasik, A. et al., J. Biol. Chem. 265: 10226-10231 (1990); Chen, K.S. et al., Trans. Assoc. Am. Physicians 104: 206-212 (1991); Chin, J.E. et al., J. Biol. Chem. 268: 6338-6347 (1993). Further, studies have 10 demonstrated a marked increase in protein kinase C activity in tissues known to be susceptible to diabetic complications when exposed to hyperglycemic conditions. Lee, T.-S. et al., J. Clin. Invest. 83: 90-94 (1989); Lee, 15 T.-S. et al., Proc. Natl. Acad. Sci. USA 86: 5141-5145 (1989); Craven, P.A. and DeRubertis, F.R. J. Clin. Invest. 83: 1667-1675 (1989); Wolf, B.A. et al., J. Clin. Invest. 87: 31-38 (1991); Tesfamariam, B. et al., J. Clin. Invest. 87: 1643-1648 (1991); Bastyr III, E.J. and Lu, J., 20 Diabetes 42: (Suppl 1) 97A (1993).

The novel compounds of the present invention, as an inhibitor of protein kinase C, are useful in the treatment of conditions in which protein kinase C has demonstrated a role in the pathology. Conditions recognized in the art 25 include: diabetes mellitus and its complications, ischemia, inflammation, central nervous system disorders, cardiovascular disease, dermatological disease, Alzheimer's disease, and cancer.

Protein kinase C inhibitors have been shown to 30 block inflammatory responses such as neutrophil oxidative burst, CD3 down-regulation in T-lymphocytes, and phorbol-induced paw edema. Twoemy, B. et al. Biochem. Biophys. Res. Commun. 171: 1087-1092 (1990); Mulqueen, M.J. et al. Agents Actions 37: 85-89 (1992). Accordingly, as

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inhibitors of PKC, the present compounds are useful in treating inflammation.

Protein kinase C activity plays a central role in the functioning of the central nervous system. Huang, K.P. 5 Trends Neurosci. 12: 425-432 (1989). In addition, protein kinase C inhibitors have been shown to prevent the damage seen in focal and central ischemic brain injury and brain edema. Hara, H. et al. J. Cereb. Blood Flow Metab. 10: 10 646-653 (1990); Shibata, S. et al. Brain Res. 594: 290-294 (1992). Recently, protein kinase C has been determined to be implicated in Alzheimer's disease. Shimohama, S. et al., Neurology 43: 1407-1413 (1993). Felsenstein, K.M. et al., Neuroscience Letters 174: 173-76 (1994). Accordingly, the compounds of the present invention are useful in 15 treating Alzheimer's disease and ischemic brain injury.

Protein kinase C activity has long been associated with cell growth, tumor promotion and cancer. Rotenberg, S.A. and Weinstein, I.B. Biochem. Mol. Aspects Sel. Cancer 1: 25-73 (1991). Ahmad et al., Molecular Pharmacology, 43: 20 858-862 (1993). It is known that inhibitors of protein kinase C inhibitors are effective in preventing tumor growth in animals. Meyer, T. et al. Int. J. Cancer 43: 851-856 (1989); Akinagaka, S. et al. Cancer Res. 51: 4888-4892 (1991). The novel compounds of the present 25 invention also act as multidrug reversal (MDR) agents making them effective compounds when administered in conjunction with other chemotherapeutic agents.

Protein kinase C activity also plays an important role in cardiovascular disease. Increased protein kinase C activity in the vasculature has been shown to cause 30 increased vasoconstriction and hypertension. A known protein kinase C inhibitor prevented this increase. Bilder, G.E. et al. J. Pharmacol. Exp. Ther. 252: 526-530 (1990). Because protein kinase C inhibitors demonstrate

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inhibition of the neutrophil oxidative burst, protein kinase C inhibitors are also useful in treating cardiovascular ischemia and improving cardiac function following ischemia. Muid, R.E. et al. FEBS Lett. 293: 5 169-172 (1990); Sonoki, H. et al. Kokyu-To Junkan 37: 669-674 (1989). The role of protein kinase C in platelet function has also been investigated and as shown elevated protein kinase C levels being correlated with increased response to agonists. Bastyr III, E.J. and Lu, J. Diabetes 10 42: (Suppl. 1) 97A (1993). PKC has been implicated in the biochemical pathway in the platelet-activity factor modulation of microvascular permeability. Kobayashi et al., Amer. Phys. Soc. H1214-H120 (1994). Potent protein kinase C inhibitors have been demonstrated to affect 15 agonist-induced aggregation in platelets. Toullec, D. et al. J. Biol. Chem. 266: 15771-15781 (1991). Protein kinase C inhibitors also block agonist-induced smooth muscle cell proliferation. Matsumoto, H. and Sasaki, Y. Biochem. Biophys. Res. Commun. 158: 105-109 (1989). 20 Therefore, the present novel compounds are useful in treating cardiovascular diseases, atherosclerosis and in particular, restenosis.

Abnormal activity of protein kinase C has also been linked to dermatological disorders such as psoriasis. 25 Horn, F. et al. J. Invest. Dermatol. 88: 220-222 (1987); Raynaud, F. and Evain-Brion, D. Br. J. Dermatol. 124: 542-546 (1991). Psoriasis is characterized by abnormal proliferation of keratinocytes. Known protein kinase C inhibitors have been shown to inhibit keratinocyte 30 proliferation in a manner that parallels their potency as PKC inhibitors. Hegemann, L. et al. Arch. Dermatol. Res. 283: 456-460 (1991); Bollag, W.B. et al. J. Invest. Dermatol. 100: 240-246 (1993). Accordingly, the novel compounds as inhibitors of PKC are useful in treating

psoriasis.

The ability of the compounds of the present invention to selectively inhibit protein kinase C beta-1 and beta-2 isozyme was determined in the PKC Enzyme assay.

5

PKC Enzyme Assay

PKC enzymes = alpha, beta I, beta II, gamma, delta, epsilon, eta and zeta.

Assay components in a total volume of 250 μ L are
10 the following:

Vesicles consisting of 120 μ g/mL phosphatidylserine (Avanti Polar Lipids) and sufficient diacylglycerol (Avanti Polar Lipids) to activate the enzyme to maximum activity in 20 mM HEPES buffer (Sigma, St. Louis, Missouri), pH 7.5, 940 μ M
15 calcium chloride (Sigma, St. Louis, Missouri) for assaying the alpha, beta I, beta II and gamma enzyme only, 1 mM EGTA for all the enzymes, 10 mM magnesium chloride (Sigma, St. Louis, Missouri) and 30 μ M (gamma-32P) ATP (DuPont). For all the enzymes either histone type HL (Worthington) or
20 myelin basic protein is used as substrate. The assay is started by addition of protein kinase C enzyme incubated at 30° C for 10 minutes and stopped by adding 0.5 mL of cold trichloroacetic acid (Amresco) followed by 100 μ L of 1 mg/mL bovine serum albumin (Sigma, St. Louis, Missouri).
25 The precipitate is collected by vacuum filtration on glass fiber filters employing a TOMTEC™ filtration system and quantified by counting in a beta scintillation counter.

Using the methodology described, representative compounds were evaluated and were found to have an IC₅₀ 30 value with respect to the beta-1 and beta-2 isozyme of below 10 μ m. Surprisingly, the compounds are isozyme selective, i.e., the compounds preferentially inhibit protein kinase C beta-1 and beta-2 isozyme over the protein kinase C isozymes, alpha, gamma, delta, epsilon, zeta, and

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eta. In general, the compounds demonstrate a minimum of a ten fold differential in the dosage required to inhibit PKC beta-1 or beta-2 isozyme and the dosage required for equal inhibition of the alpha protein kinase C isozyme as measured in this assay. Therefore, as selective inhibitors of PKC isozyme beta-1 and beta-2, the compounds are useful in the treatment of conditions in which PKC beta isozymes have demonstrated a role in the pathology, in particular, diabetes mellitus and its complications.

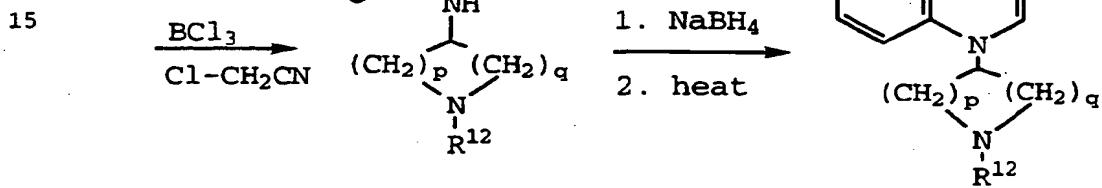
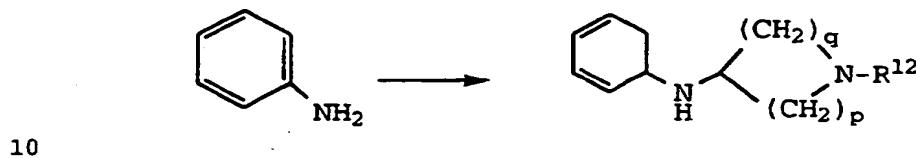
10 The following examples and preparations are provided merely to further illustrate the invention. The scope of the invention is not construed as merely consisting of the following examples. In the following examples and preparations, melting point, nuclear magnetic 15 resonance spectra, mass spectra, high pressure liquid chromatography over silica gel, N,N-dimethylformamide, palladium on charcoal, diisobutylaluminum hydride, acetonitrile, and tetrahydrofuran are abbreviated M.Pt., NMR, MS, HPLC, DMF, Pd/C, DIBAL, ACN and THF, respectively. 20 The terms "NMR" and "MS" indicate that the spectrum was consistent with the desired structure. The term "ND" indicates that data are not available.

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Preparation 1

5



20 The above reaction is carried out in a manner analogous to M. Adachi et al., Chem. Pharm. Bull., 33(5), 1826-35 (1985); and K. Sasakura et al., Synth. Commun., 18(3), 265-273 (1988).

25

Preparation 2

2-(1-(1-N(H)-piperidin-4-yl)-indol-3-yl)-acetic acid ethyl ester

To a solution of 4-(1-indolyl)-piperidine (300 mg, 1.5 mmol) was added dry ethanol (3 mL) and anhydrous potassium carbonate (410 mg, 3 mmol). After 20 minutes, ethyl bromoacetate (0.17 mL, 1.5 mmol) was added. After 12 hours, the reaction was quenched with water, extracted with ethyl acetate (3x), washed with water, dried, and concentrated to a residue. The residue was eluted through

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a column of silica gel with toluene/acetone (80:20). Evaporation of the eluding solvent gave of the title compound (300 mg) as a brownish oil (70% of theory).

5

Preparation 31-(1-Ethyl-piperidin-4-yl)-1H-indole

To a solution of 1-piperidin-4-yl-1H-indole (0.6 g, 3 mmol) in 5 mL of dry ethanol was added anhydrous potassium carbonate (680 mg, 4.9 mmol). After stirring for 10 15 minutes at ambient temperature, ethyl p-toluenesulfonate (0.48 mL, 4.5 mmol) was added. The reaction was heated under reflux for 24 hours with stirring, quenched with water, extracted with methylene chloride (2x), dried and evaporated to give a residue. The residue was 15 chromatographed on silica gel with toluene/acetone (50:50) to yield 360 mg straw colored material (53% of theory).

Preparation 41-[(1-N-Cyclopropylmethyl)-piperidine-4-yl]-indole

20 To a solution of 4-(1-indolyl)-piperidine (0.6 g, 3 mmol) in dry ethanol (4 mL) was added anhydrous potassium carbonate (680 mg, 4.9 mmol). After 15 minutes, bromomethylcyclopropane (0.29 mL, 4.5 mmol) was added and stirring was continued over night. Additional potassium 25 carbonate (0.22 g) and bromomethylcyclopropane (0.14 mL) was added. After 3 hours, the reaction mixture was quenched with water and extracted with ethyl acetate (3x). The combined organic phases were washed with water, dried, evaporated, and purified by column chromatography on silica 30 gel eluting with methylene chloride/ethanol (98:2). Evaporation of the eluting solvent gave the title compound. 480 mg (63% yield).

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Preparation 5

1-N-[1-N-(3-chloropropyl)-piperidin-4-yl]-indole

To a solution of 1-(piperidin-4-yl)-indole (1 mg, 0.5 mmol) in absolute ethanol (2 mL) was added anhydrous 5 potassium carbonate (70 mg, 0.5 mmol) and 1-bromo-3-chloropropane (150 mg, 1 mmol). After stirring overnight additional 1-bromo-3-chloropropane (150 mg) was added and stirring continued for 2 hours. The mixture was 10 evaporated; and the residue dissolved in methylene chloride and shaken with water. The organic solution was dried over anhydrous potassium carbonate and evaporated. The residue was chromatographed on silica gel with methylene chloride/ethanol (95:5) to give the title compound (90 mg, 65% yield).

15

Preparation 6

[3-(4-Indol-1-yl-piperidin-1-yl)-propyl]-dimethylamine

A mixture of 1-N-[1-N-(3-chloro-propyl)-piperidin-4-yl]-indole (900 mg, 3.25 mmol), anhydrous potassium 20 carbonate (440 mg, 3.25 mmol) and dimethylammonium hydrochloride (260 mg, 3.25 mmol) in absolute ethanol (10 mL) was refluxed for 6 hours, evaporated and suspended in water. The mixture was extracted with methylene chloride, dried over anhydrous potassium carbonate, and evaporated to 25 yield 1 g of the desired compound (100% of theory).

Preparation 7

1-Benzyl-4-(1-indolyl)-piperidine

This compound was prepared in a manner analogous to 30 the synthesis described in the literature: a) M. Adachi et al., Chem. Pharm. Bull., 33(5), 1826-35 (1985); b) K. Sasakura et al., Synth. Commun., 18(3), 265-273 (1988).

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Preparation 8

1-t-butoxycarbonyl-4-(1-indolyl)-piperidine

To a 0°C methylene chloride (20 mL) solution of 5
tert-butoxycarbonate (5.44 mmol) containing triethylamine
(0.76 mL, 5.44 mmol) was added 4-(1-indolyl)-piperidine
(1.09 g, 5.44 mmol). The reaction was brought to room
temperature. After 4 hours, the reaction was quenched with
sat NaHCO₃, water (2 x), dried, filtered and concentrated.
The residue was purified by flash chromatography eluting
10 with methylene chloride to give the title compound 1.25 g
(76% yield) as an oil which crystallized on standing.

Preparation 9

4-(1-indolyl)-piperidine

15 A glacial acetic acid (15 mL) solution containing
Pd(OH)₂ /C and 1-benzyl-4-(1-indolyl)-piperidine was placed
under an H₂ atmosphere. The reaction temperature was
raised to 80°C. After 1 hour, the reaction was cooled to
room temperature and filtered. The filtrate was made basic
20 (pH 8-9) with saturated NaHCO₃, and extracted with
methylene chloride. The extract was washed with water,
dried, and concentrated. This material was sufficiently
pure for further reactions giving 1.09 g (80% yield) of the
title compound.

25

Preparation 10

6,7,8,9-tetrahydropyrido[1,2-a]indole-8,8-dicarboxylic acid
diethyl ester

To a -78°C THF (12 mL) solution of lithium
30 diisopropylamide (generated in situ from diisopropylamine
(3.8 mL) and 15% n-butyl lithium in hexane (17 mL) at 0°C)
was added dropwise a THF solution of 6,7,8,9-
tetrahydropyrido[1,2-a]indole-8-carboxylic acid ethyl
ester. After 30 minutes, the temperature was brought to

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0°C. After 1 hour, ethyl chloroformate (2.6 mL) was added over one hour. The reaction was allowed to come to room temperature overnight. The reaction was quenched with saturated NH₄Cl and extracted t-butyl methyl ether (3x).

5 The extract was washed with water, dried, filtered, and concentrated to give a residue. The residue was purified by flash chromatography eluting with 15% ethyl acetate/hexane to give the title compound 1.29 g (33% yield) as off white crystals (M.Pt. 69°C).

10

Preparation 11

1-(1-Methyl-piperidin-4-yl)-indole

To an ice cooled solution of 4-indol-1-yl-piperidine-1-carboxylic acid ethyl ester (50 g, 0.18 mol) in dry THF (400 mL) was added LAH in small portions (7 g, 0.18 mol). After 2 hours, the mixture was quenched by successive addition of water (7 mL) 15% of sodium hydroxide (7 mL) and water (21 mL). The reaction mixture was filtered. The filtrate was dried and evaporated. The residue crystallized on standing and was recrystallized from a small amount of di-i-propyl ether to give the title compound (25 g, 63% of theory). M.Pt.: 58°C

Preparation 12

25 4-(Indol-1-yl)-piperidine-1-carboxylic acid ethyl ester

To a solution of 1-N-(1-benzyl-piperidin-4-yl)-indole (100 g, 0.344 mol) in methylene chloride (1 L) was added ethyl chloroformate (99.2 mL) dropwise with stirring. The mixture was refluxed for 48 hours, cooled to room temperature, and concentrated. The residue was crystallized from i-propanol to give the title compound as colorless crystals (50 g, 53% yield). M.Pt.: 127°C.

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Preparation 13

1-N-(1-N-(Cyclopropylmethyl)-piperidin-4-yl)-indole

To a solution of 1-N-(piperidin-4-yl)-indole (0.6 g, 3 mmol) in dry ethanol (4 mL) was added anhydrous 5 potassium carbonate (680 mg, 4.9 mmol). After stirring for 15 minutes at ambient temperature, bromomethylcyclopropane (0.29 mL, 4.5 mmol) was added. Stirring was continued overnight. An additional amount of carbonate (0.22 g) and bromomethylcyclopropane (0.14 mL) was added. After 3 10 hours, the reaction mixture was quenched with water and extracted with ethyl acetate (3x). The combined organic phase was washed with water, dried, evaporated, and purified by column chromatography on silica gel eluting with methylene chloride/ethanol (98:2). Evaporation of the 15 eluting solvent gave the title compound as an oil (480 mg, 63% yield).

Preparation 14

1-N-(1-N-i-Propyl-piperidin-4-yl)-1H-indole

20 To a solution of 1-(piperidin-4-yl)-indole (0.5 g, 2.5 mmol) in dry DMF (3 mL) was added anhydrous potassium carbonate (360 mg, 2.6 mmol). After stirring for 15 minutes at ambient temperature, i-propyl bromide (0.84 mL, 9 mmol) was added. The reaction mixture was refluxed for 2 25 days with stirring, quenched with water, extracted with ethyl acetate (2x), dried, and evaporated. The remaining residue was chromatographed on silica gel eluting with a toluene/acetone gradient (90:10 to 70:30). Evaporation of the eluting solvent gave the title compound as an oil. 30 (220 mg, 36% yield).

Preparation 15

1-N-[1-N-(2,2,2-Trifluoro-ethyl)-piperidin-4-yl]-indole

To a solution of 1-N-(1-N-(trifluoroaceto)

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piperidin-4-yl)-indole (400 mg, 1.35 mmol) in dry THF (3 mL) was added dropwise a 10 N solution of borane methyl sulfide (0.15 mL) complex. The mixture was stirred at 60°C for 3 hours, cooled, quenched with 2N aqueous sodium hydroxide, and brought to pH 10. The mixture was diluted with water and extracted with t-butyl methyl ether (2x). The combined organic solutions were washed with water (2x), dried, and evaporated. The residue solidified on standing and was recrystallized from hexane to give the title compound as colorless crystals (190 mg, 50% yield). M.Pt.: 79-81°C.

Preparation 16

1-N-(1-N-(trifluoroacetyl)piperidin-4-yl)-indole

15 To an ice cooled solution of 1-N-(piperidin-4-yl)-indole (1.0 g, 5 mmol) in dry pyridine (5 mL) was carefully added trifluoroacetic acid anhydride (0.71 mL, 5 mmol). After stirring for 48 hours at ambient temperature, all volatiles were evaporated. The residue was redissolved and evaporated with toluene (x2). The residue was taken up in water and extracted twice with t-butyl methyl ether. The combined organic phase was washed with water, dried, and evaporated. The residue was triturated with ether. The crystalline precipitate formed was separated and discarded.

20 After evaporation of the filtrate, the residue was purified by column chromatography on silica gel eluting with toluene/acetone 98:2 to give 410 mg of off white crystals (28% of theory). M.Pt.: 130-132°C.

25

30

Preparation 17

1-N-[1-N-(2,2,3,3,4,4,4-Heptafluoro-butyl)-piperidin-4-yl]-indole

To a solution of 1-N-[(1-N-2,2,3,3,4,4,4-heptafluoro)butyramido-piperidin-4-yl]-indole (750 mg, 1.89

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mmol) in 5 mL of absolute THF was added dropwise a 10 N solution of borane methyl sulfide (0.19 mL) complex. The mixture was stirred at 60°C for 3 hours. After cooling, 5 and brought to pH 10, diluted with water and extracted with t-butyl methyl ether twice. The combined organic solutions were washed with water twice, dried, and evaporated. The residue was chromatographed on silica gel with toluene as the eluant. The eluant was evaporated to give 430 mg of a 10 yellowish oil (60% of theory).

Preparation 18

1-N-[(1-N-2,2,3,3,4,4,4-heptafluoro)butyramido-
piperidin-4-yl]-indole

15 To an ice cooled solution of 1-N-(piperidin-4-yl)-indole (1.0 g, 5 mmol) in dry pyridine (3 mL) was carefully added heptafluorobutyric acid chloride (0.75 mL, 5 mmol). After stirring for 16 hours at ambient temperature, the mixture was quenched with water and extracted with ethyl 20 acetate (3x). The combined organic phase was washed with water, dried, and evaporated. The residue was purified by column chromatography on silica gel eluting with toluene/acetone 97:3 to give 1.34 g of brownish oil (68% of theory).

25

Preparation 19

1-t-Butoxycarbonylimino-(4-indol-1-yl-piperidin-1-yl)-
methyl-carbamic acid t-butyl ester

This material was prepared by the known procedure. 30 Tetrahedron Letters 1993, 34(48), 7677. To an ice cooled solution of 1-piperidin-4-yl-1H-indole (0.6 g, 3 mmol), N,N-bis-t-butoxycarbonylthiourea (0.83 g, 3 mmol) and triethylamine (1.38 g, 9.9 mmol) in dry DMF (5 mL) was carefully added copper(II) chloride dihydrate (exothermic)

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(0.56 g, 3.3 mmol). After stirring for 30 minutes at ambient temperature, the mixture was diluted with ethyl acetate and filtered over Hyflo. The filtrate was washed twice each with brine and water, dried, evaporated. The residue was purified by column chromatography on silica gel eluting with toluene/acetone 95:5. 0.61 g of yellow crystals (46 % of theory). M.Pt.: 115-118°C.

Preparation 20

10 1-N-(1-Methyl-piperidin-4-yl)methylene)-indole

To an ice cooled stirred suspension of lithium aluminum hydride (LAH) (85 mg, 2.24 mmol) in absolute THF (7 mL) was added 4-(indol-1-yl)methylenepiperidine-1-carboxylic acid ethyl ester (0.64 g, 2.23 mmol) in 4 mL of absolute THF and then stirred at ambient temperature. After 2 hours, additional LAH (85 mg, 2.24 mmol) was added and stirring continued for 1 hour. The mixture was cooled to 0°C and quenched by successive addition of water (0.17 mL), 15% aqueous sodium hydroxide (0.17 mL), water (0.51 mL), stirred for 30 minutes, filtered, and evaporated to dryness. The residue was taken up in water (40 mL) and extracted (2x) with t-butyl methyl ether (30 mL). The combined organic phases were washed with water (2x), dried, and evaporated. The remaining oily residue was sufficiently pure for further reaction.

Preparation 21

4-(Indol-1-yl)methylene-piperidine-1-carboxylic acid ethyl ester

To a stirred solution of indole (0.53 g, 4.5 mmol) in dry DMF (15 mL) was added potassium t-butoxide (580 mg, 5.2 mmol) at ambient temperature. After stirring for 30 minutes, 4-(methanesulfonyloxymethylene)-piperidine-1-carboxylic acid ethyl ester (1.2 g 4.5 mmol) was added.

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After 8 hours, the reaction mixture was quenched with water and extracted with t-butyl methyl ether (2x50 mL). The combined organic phases were washed with water (2x), dried, evaporated, and purified by column chromatography on silica gel eluting with toluene/ acetone 96:4. Evaporation of the eluting solvent gave 0.92 g (71 % of theory) of a slightly bluish oil.

Preparation 22

10 2-(Indol-1-yl)butyrolactone

An ice cooled solution of indole (9 g, 78 mmol) in dry THF (80 mL) was treated with oil free sodium hydride (2.25 g, 94 mmol). After 1 hour, a solution of 2-bromobutyrolactone (14.6 mL, 78 mmol) in dry THF (20 mL) was added dropwise. After stirring overnight at ambient temperature, the mixture was poured on crushed ice, extracted with ethyl acetate (3x), dried, and evaporated. The residue was purified by flash chromatography on silica gel with a hexane/ethyl acetate gradient (9:1 to 7:3). Evaporation of the eluting solvent gave 8 g of a yellowish oil (52% of theory).

Preparation 23

2-(Indol-1-yl)-butane-1,4-diol

25 To an ice cooled suspension of LAH (0.84 g, 0.022 mol) in dry THF (60 mL) was added 2-(indol-1-yl)butyrolactone (4 g, 0.02 mol). After 1 hour the mixture was quenched successively with water (0.84 mL), 15% aqueous sodium hydroxide (0.84 mL), and water (2.5 mL). The 30 reaction was filtered and the filtrate was dried, and evaporated. The material obtained, 2.5 g of colorless oil (61% of theory), was used directly in the next reaction.

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Preparation 24

1,4-(Bis)methanesulfonyloxy-2-(indol-1-yl)-butane

An ice cooled solution of 2-(indol-1-yl)-butane-1,4-diol (2 g, 10 mmol) containing triethylamine (3.6 mL, 26 mmol) in dry methylene chloride (30 mL) was treated with methanesulfonyl chloride (1.86 mL, 12 mmol). After stirring over night, the mixture was poured onto crushed ice, extracted with methylene chloride (3x), dried, and evaporated. The crude material, 2.5 g (71% of theory) was used in the next reaction.

Preparation 25

1,4-Diodo-2-indol-1-yl-butane

An acetone solution (20 mL) containing 1,4-(bis)methanesulfonyloxy-2-(indol-1-yl)-butane (0.5 g, 1.4 mmol) and sodium iodide (1.86 g, 12.5 mmol) was refluxed for 4 hours, cooled, and filtered. The filtrate was evaporated. The residue, 400 mg (70% of theory), was used directly in the next reaction.

20

Preparation 26

1-N-(1-Benzyl-pyrrolidin-3-yl)-indole

To a solution of 1,4-diodo-(2-indol-1-yl)-butane (400 mg, 0.94 mmol) in THF (20 mL) was added successively benzyl amine (0.12 mL, 1.07 mmol) and triethyl amine (0.15 mL, 2.9 mmol). The mixture was refluxed for 1 hour and evaporated. The residue was dissolved in t-butyl methyl ether. The organic solution was washed with water (2x), dried, and evaporated. The oily residue was purified by HPLC on silica gel using methylene chloride/ethanol (98:2). Evaporation of the eluting solvent gave 110 mg of a pale oil (42% of theory).

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Preparation 27

1-N-(1-Benzhydryl-azetidin-3-yl)-indole

A solution of 2-[2-(1-(benzhydryl)-azetidin-3-yl)-2-amino)-phenyl]-ethanol (3.1 g, 0.01 mol) in dry 5 methylene chloride (100 mL) was cooled to -5°C and treated with pyridinium dichromate (PDC) (9.3 g) in small portions. The mixture was slowly brought to ambient temperature and additional PDC (9.3 g) was added. After 1 hour, the 10 mixture was filtered through a layer of dry silica gel, rinsed with methylene chloride diethyl ether after evaporation of the eluant. (0.85 g) a yellow oil, which was used without further purification. (25% of theory). MS

Preparation 28

15 1-N-(1-N-(benzhydryl)-azetidin-3-yl)-2-(ethan-2-ol)-analine

A mixture of methanesulfonic acid 1-benzhydryl-azetidin-3-yl ester (14 g, 44.2 mmol), 2-(ethan-2-ol)-analine (14 g, 44.2 mmol), and anhydrous potassium carbonate (2.8 g, 50 mmol) in dry toluene (150 mL) was 20 refluxed for 4 hours. The toluene was evaporated, and the residue was partitioned between water and methylene chloride. The organic phase was dried, evaporated, and the remaining oil was purified by column chromatography on silica gel eluting with a hexane/acetone gradient (90:10 to 25 85:15). Evaporation of the eluting solvent gave 6 g of a colorless oil (44% of theory). MS

Preparation 29

Methanesulfonic acid 1-benzhydryl-azetidin-3-yl ester

30 A solution of 1-benzhydryl-azetidin-3-ol (50 g, 0.208 mol) in dry pyridine (500 mL) was cooled to 5°C. Methane sulfonyl chloride (16.2 mL, 0.208 mol) was added over 30 minutes. The mixture was slowly (12 hours) brought to ambient temperature and stirring was continued for

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additional 2 hours. The solvent was removed in vacuo at 40 to 50°C. The residue was redissolved in methylene chloride, washed with water (2x), and dried. The crude material was triturated with a solution of 5 t-butylmethylether/petroleum ether (15:85), to produce the purified product as crystals. (53g, 80% yield). M.Pt.: 85-87°C. MS

Preparation 30

10 Methyl-2-deoxy-5-O-tosyl-D-ribose
Methyl-2-deoxy-D-ribose (8 g, 54 mmol) was dissolved in pyridine (60 mL). To this solution was added tosylchloride (10.86 g, 57 mmol) over 1 hour at 0°C. After 14 hours at room temperature, the solution was 15 concentrated, quenched with ice water (250 mL), and extracted with ethyl acetate. The extract was washed with saturated NaHCO₃, water, dried, filtered, and concentrated. The residue (13.6 g, 83.5% yield) was used directly. NMR

20 Preparation 31

Methyl-5-azido-2.5 dideoxy-D-ribose

To a solution of methyl-2-deoxy-5-O-tosyl-D-ribose (13.6 g, 45 mmol) in DMF (250 mL) was added sodium azide (4.4 g, 67 mmol). The mixture was refluxed for 4 hours, 25 cooled to room temperature, quenched with ice water (1.5 mL), and extracted with ethyl-acetate. The extract was washed with water, dried, and concentrated to give an oil (6.2g, 86% yield). NMR

30 Preparation 32

Methyl-3-O-acetyl-5-azido-2.5-dideoxy-D-ribose

Acetic anhydride (25 mL) was added to a solution of methyl-5-azido-2.5-dideoxy-D-ribose (6.2 g, 38 mmol) in pyridine (100 mL). After 4 hours at room temperature, the

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mixture was concentrated in vacuo. The residue (6 g) was purified by flash chromatography eluting with hexanethylacetate (8:2). Evaporation of the eluting solvent gave the product as an oil (4.9 g, 60% yield). NMR

5

Preparation 33

3-O-Acetyl-5-azido-2,5-dideoxy-D-ribosylacetate

To a 25°C cooled solution of methyl-3-O-acetyl-5-azido-2,5-dideoxy-D-ribose (2.5 g, 11.6 mmol) in acetic anhydride (30 mL) was added acetic anhydride containing trace sulfuric acid (26 mL, 50:1). After 45 minutes, the mixture was diluted with methylene chloride (300 mL), quenched with saturated NaHCO₃, washed with water, dried, filtered and concentrated. The residue was purified by flash chromatography eluting with hexan-ethylacetate (8:2).

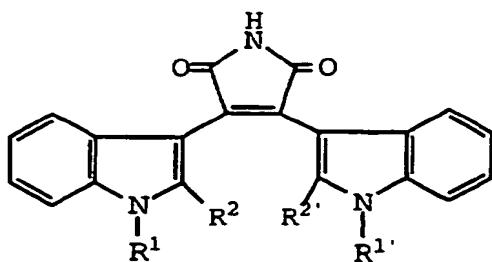
Preparation 34

8,8-bis(acetoxyethylene)-6,7,8,9-tetrahydropyrido[1,2-a]indole

To a toluene (4 mL) solution of 8,8'-bis(acetoxyethylene)-6,7,8,9-tetrahydropyrido[1,2-a]indole-8,8'-dicarboxylic acid diethyl ester (1.2 g, 3.8 mmol) was added a hexane solution of 1 M diisobutylaluminum hydride. After 1 hour, acetic anhydride (15 mL) was added. After an additional 15 hours, 4-dimethylaminopyridine (100 mg) was added, and the reaction temperature brought to 65°C for 3 hours. The reaction was filtered, washing with t-butylmethyl ether. The filtrate was washed with water, dilute aqueous HCl, saturated NaHCO₃, and water. Evaporation of the solvents gave a residue that was purified by chromatography eluting with 60% hexane/acetone to give the title compound in 42% yield.

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Example 1

3-[8,8'-bis(acetoxyethylene)-6,7,8,9-tetrahydropyrido[1,2-a]indol-10-yl]-4-(1-methyl-3-indolyl)-1H-pyrrole-2,5-dione

To a 0°C methylene chloride (2.5 mL) solution of 8,8'-bis(acetoxyethylene)-6,7,8,9-tetrahydropyrido[1,2-a]indol (220 mg, 0.7 mmol) was added oxalyl chloride (0.067 mL, 0.84 mmol). The reaction temperature was raised to room temperature for 15 minutes and concentrated in vacuo. To a 0°C toluene (5 mL) solution of the concentrate containing isopropyl(1-methylindol-3-yl)acetimidate hydrochloride was added dropwise triethylamine (0.4 mL, 0.028 mmol). The reaction was warmed to room temperature. After 1 hour, the reaction was poured into 1% aqueous HCl (50 mL), extracted with toluene, dried, and filtered. The filtrate was treated with p-toluene sulfonic acid hydrate (260 mg, 14 mmol). After 1 hour, the filtrate was washed with water, saturated NaHCO₃, dried, filtered, and concentrated to give a residue. The residue was recrystallized from t-butyl ether/hexane to give the title compound 150 mg (40% yield) as red crystals (M.Pt. 245°C).

Alternatively, the compound is prepared in a manner analogous the methods described in EPA 0 384 349, Tetrahedron Lett., 31(16) 2353-2356 (1990) and Tetrahedron Lett., 31(36) 5201-5204 (1990).

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		IC ₅₀ (μm)							
Example 1		α	β1	β2	γ	δ	ε	ζ	η
5	R ¹ R ²	9.8	0.36	0.3	38	47	150	50	121
	-CH ₂ CH ₂ CR ⁸ R ⁹ CH ₂ -								
	R ⁸	-CH ₂ OCOCH ₃							
	R ⁹	-CH ₂ OCOCH ₃							
	R ¹	CH ₃							
	R ²	H							

10

Example 23-[8,8-bis(hydroxymethylene)-6,7,8,9-tetrahydropyrido[1,2-a]indol-10-yl]-4-(1-methyl-3-indolyl)-1H-pyrrole-2,5-dione

To an ethanol (3 mL) solution of sodium ethoxide (0.4 mmol) was added 3-[8,8'-bis(acetoxyethylene)-6,7,8,9-tetrahydropyrido[1,2-a]indol-10-yl]-4-(1-methyl-3-indolyl)-1H-pyrrole-2,5-dione (80 mg, 0.15 mmol). After 2 hours, the reaction was acidified with acetic acid to pH 4, diluted with water (10 mL) and extracted with methylene chloride. Evaporation of the organic phase gave the title compound 60 mg (89% yield) as red crystals (M.Pt. 242-244°C).

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		IC ₅₀ (μm)							
Example 2		α	β1	β2	γ	δ	ε	ζ	η
5	R ¹ R ²	3.5	0.070	0.060	8.8	6.8	31.8	33	5.7
	-CH ₂ CH ₂ CR ⁸ R ⁹ CH ₂ -								
	R ⁸ -CH ₂ OH								
	R ⁹ -CH ₂ OH								
	R ¹ CH ₃								
	R ² H								

10

Example 3

3-[(1-[2-(5-Acetamido-2,5-dideoxy- α -D-ribopyranosyl)-hydroxyethyl]-3-indolyl)-4-(1-methyl-3-indolyl)-1H-pyrrole-2,5-dione

15

The titled compound was prepared in a manner analogous to Example 37. α anomer: ¹H-NMR (CDCl₃): 1.9 (3H, s, NAc), 2.2 (2H, m, H-2ab), 3.8 (2H, m, CH₂), 3.85 (3H, s, NCH₃), 4.2 (2H, m, CH₂), 5.05 (1H, d, H-1), 6.7-7.8 (10H, indole H), 8.4 (1H, s, NH)

20

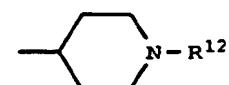
		IC ₅₀ (μm)							
Example 3		α	β1	β2	γ	δ	ε	ζ	η
25	R ¹	0.32	0.036	0.025	4.4	0.41	0.60	46	1.1
	R ² H								
	R ¹ ' CH ₃								
	R ² ' H								

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Example 43-[1-[4-(1-benzyl)-piperidinyl]-3-indolyl]-4-(1-methyl-3-indolyl)-1H-pyrrole-2,5-dione

To a 0°C methylene chloride (2.5 mL) solution of 5 1-benzyl-4-(1-indolyl)piperidine (290 mg, 1 mmol) was added oxalyl chloride (0.10 mL). The reaction was brought to room temperature. After 30 minutes, the volatiles were removed in vacuo below 30°C. The residue was dissolved in methylene chloride (25 mL) and added dropwise to a 10 methylene chloride (20 mL) solution of isopropyl(1-methyl)indol-3-yl)acetimidate hydrochloride (270 mg, 1 mmol) containing triethylamine (4 mmol) and 4A molecular sieves (2.8 g). After 18 hours, p-toluene sulfonic acid (950 mg, 5 mmol) was added. After 2 hours, the reaction 15 was filtered. The filtrate washed with saturated NaHCO₃, water (2 x), dried, filtered, and concentrated. The concentrate was purified by flash chromatography eluting with 10% acetone/toluene to give the title compound 50 mg (10% yield) as red crystals. MS. ¹H-NMR (CDCl₃, 250 MHz) 20 δ 2.02 - 2.26 (6H, m), 3.06 (2H, m), 3.64 (2H, s), 3.84 (3H, 2), 4.24 (1H, m), 6.68 (1H, m), 6.81 (2H, m), 7.11 (3H, m), 7.28 (7H, m), 7.69 (1H, s), 7.85 (1H, s), 8.50 (1H, bs). MS 515 [M⁺+H], calculated. 514 FW.

25	Example 4	IC ₅₀ (μm)								
		α	β ₁	β ₂	γ	δ	ε	ζ	η	
30	 R ¹	6	0.05	0.03	7	6	4	>100	0.5	
	R ² H									
	R ^{1'} CH ₃									
	R ^{2'} H									
	R ^{12'} benzyl									

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Example 5

To a stirred 0°C solution of {t-butoxycarbonylimino-(4-indol-1-yl-piperidin-1-yl)-methyl}-carbamic acid t-butyl ester (0.85 g, 1.92 mmol) in dry methylene chloride (5 mL) was added oxalyl chloride (0.18 mL, 2.11 mmol). After 30 minutes at room temperature, the reaction mixture was concentrated below 30°C, dissolved in dry methylene chloride (10 mL), and treated with isopropyl(1-methyl)indol-3-ylacetimidate hydrochloride (0.54 g, 2.02 mmol). Triethylamine (0.54 g, 2.02 mmol) was added at 0°C. The mixture was stirred at ambient temperature for 3 hours. p-Toluene sulfonic acid monohydrate (1.8 g, 9.6 mmol) was added to the reaction. After 30 minutes, the reaction was quenched with saturated Na_2CO_3 (40 mL). The organic phase was separated, washed with Na_2CO_3 (sat. aq.), brine, water, dried, and evaporated. The residue was purified by column chromatography on silica gel eluting with toluene/acetone (9:1). Evaporation of the eluting solvent gave a residue. The residue was recrystallized from diisopropyl ether (150 mg), work up of the mother liquor yielded a second crop (60 mg). Overall yield: 210 mg of bright orange crystals (16% of theory). M.Pt.: 238-245°C. $^1\text{H-NMR}$ (CDCl_3 , 250 MHz) δ 1.49 (18H, s), 2.02 (2H, m), 2.02 (4H, m), 3.09 (2H, m), 3.86 (3H, s), 5.29 (3H, m), 6.66 (2H, m), 6.91 (1H, m), 7.16 - 7.36 (5H, m), 7.48 (1H, s), 7.75 (1H, s), 10.18 (1H, bs). MS 667 [M^{++}H], calculated. 666 FW.

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Example 5	IC ₅₀ (μm)								
	α	β1	β2	γ	δ	ε	ζ	η	
	0.37	0.044	0.029	0.50	0.47	2.6	42	0.15	
5									
	R ¹								
	R ² H								
10	R ^{1'} CH ₃								
	R ^{2'} H								
	R ^{12'}								
	C(=NBoc)NHBoc								

Example 6

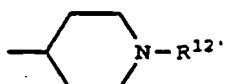
15 3-(1-[4-(1-t-butoxycarbonyl)-piperidinyl]-3-indolyl)-4-(1-methyl-3-indolyl)-1H-pyrrole-2,5-dione

To a 0°C ether (6 mL) solution of 1-t-butoxycarbonyl-4-(1-indolyl)-piperidine (690 mg, 2.3 mmol) was added oxalyl chloride (0.22 mL, 2.5 mmol). After 15 minutes, the precipitant was filtered under argon, washed with ether and dissolved in methylene chloride (5 mL). This solution was added dropwise to a 0°C methylene chloride (3 mL) solution of isopropyl(1-methyl)indol-3-yl)acetimidate hydrochloride (610 mg, 2.3 mmol) containing 25 triethylamine (9.3 mmol) and 4A molecular sieves (2.8 g). The reaction was brought to room temperature. After 4 hours, the reaction was quenched with water, washed with 0.5 N HCl. The organic layer was separated and concentrated. The residue was dissolved in pyridine (5 mL) 30 cooled to 0°C, and molecular sieves 4A (7 g) was added followed by trifluoroacetic anhydride. The reaction was brought to room temperature and after 2.5 hours and then filtered. The filtrate washed with saturated NaHCO₃, water (2 x), dried, filtered, and concentrated. The residue was

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concentrated from toluene (3 x) and purified by flash chromatography eluting with 10% acetone/toluene to give the title compound 366 mg (30% yield) of red crystals. $^1\text{H-NMR}$ (CDCl₃, 250 MHz) δ 1.48 (9H, s), 1.74 (2H, m), 2.02 (2H, m), 2.87 (2H, m), 3.85 (3H, s), 4.29 (3H, m), 6.69 (2H, d), 6.88 (1H, t), 7.07 - 7.36 (5H, m), 7.51 (1H, s), 7.68 (1H, s), 7.75 (1H, bs).

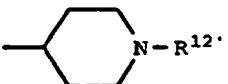
		IC ₅₀ (μm)							
Example 6		α	β_1	β_2	γ	δ	ϵ	ζ	η
10		6.1	0.22	0.082	5.3	7.3	4.4	>100	.3
15									
	R ¹								
	R ² H								
	R ₁ ' CH ₃								
	R ² ' H								
20	R ¹² ' t-butoxycarbonyl								

Example 7

3-(1-[4-(1-t-butoxycarbonyl)-piperidin-4-yl]-3-indolyl)-4-(1-methyl-3-indolyl)-1H-pyrrole-2,5-dione

25 The titled compound was prepared in a manner analogous to Example 6. $^1\text{H-NMR}$ (CDCl₃, 250 MHz) δ 1.49 (9H, m), 1.79 (2H, m), 2.02 (2H, m), 2.88 (2H, m), 4.27 (3H, m), 6.74 (1H, m), 6.85 (2H, m), 7.07 - 7.35 (5H, m), 7.59 (1H, s), 7.62 (1H, s), 7.74 (1H, s), 8.67 (1H, bs).
 30 MS 510 [M⁺], calculated. 510 FW.

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Example 7		IC ₅₀ (μm)							
		α	β1	β2	γ	δ	ε	ζ	η
5		3.3	0.23	0.10	2.8	4.1	6.3	31	6.2
	R ¹								
	R ² H								
	R ^{1'} H								
10	R ^{2'} H								
	R ^{12'} t-butoxy-carbonyl								

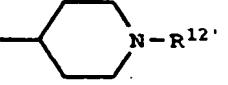
Example 8

15 3-[1-(1-i-Propyl-piperidin-4-yl)-1H-indol-3-yl]-4-(1-methyl-1H-indol-3-yl)-pyrrole-2,5-dione

The title compound was prepared analogously to

3-[1-(1-cyclopropylmethyl-piperidin-4-yl)-1H-indol-3-yl]-4-(1-methyl-1H-indol-3-yl)-pyrrole-2,5-dione.

20 Yield: 11% of theory. M.Pt.: >250°C.

Example 8		IC ₅₀ (μm)							
		α	β1	β2	γ	δ	ε	ζ	η
25		0.34	0.019	0.026	1.3	0.97	0.39	9.3	0.13
	R ¹								
	R ² H								
	R ^{1'} CH ₃								
	R ^{2'} H								
30	R ^{12'} CH(CH ₃) ₂								

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Example 93-[8-(Hydroxymethyl)-6,7,8,9-tetrahydropyrido[1,2-a]indol-10-yl]-4-(1-methyl-3-indolyl)-1H-pyrrole-2,5 dione

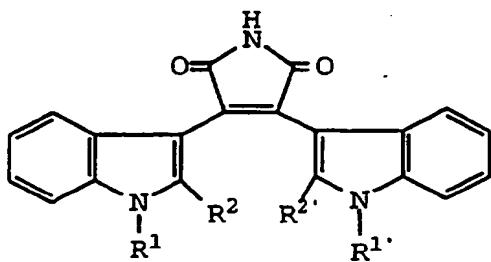
This compound was prepared as described in EP 0 540
 5 956 A1, and J. Med. Chem., 36(1), 21-29 (1993).

		IC ₅₀ (μm)							
Example 9		α	β1	β2	γ	δ	ε	ζ	η
10	R ¹ R ²	0.27	0.014	0.0061	1.5	0.44	3.8	9.26	0.40
	CH ₂ CH ₂ CR ⁸ R ⁹ CH ₂								
	R ⁸ H								
	R ⁹ CH ₂ OH								
	R ¹ CH ₃								
	R ² H								

15

The following examples were prepared in a manner analogous to the examples by techniques known in the art and described herein.

20



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Example 10	IC ₅₀ (μM)								
	α	β1	β2	γ	δ	ε	ζ	η	
R ¹ 3- 5 (dimethyl- amino)propyl	0.66	0.05	0.05	1.04	0.92	0.93	23	0.09	
R ² H									
R ^{1'} H									
R ^{2'} H									

Example 11	IC ₅₀ (μM)								
	α	β1	β2	γ	δ	ε	ζ	η	
R ¹ 3- hydroxypropyl	0.45	0.039	0.046	1.1	0.41	0.68	16	0.1	
R ² H									
R ^{1'} H									
R ^{2'} H									

Example 12	IC ₅₀ (μM)								
	α	β1	β2	γ	δ	ε	ζ	η	
R ¹ CH ₃	1.21	0.081	0.086	1.25	1	0.9	8	0.52	
R ² H									
R ^{1'} H									
R ^{2'} H									

Example 13	IC ₅₀ (μM)								
	α	β1	β2	γ	δ	ε	ζ	η	
R ¹ 3- 25 (dimethyl- amino)propyl	2.3	0.14	0.06	1.7	0.93	3.6	25	0.47	
R ² H									
R ^{1'} CH ₃									
R ^{2'} H									

Example 14	IC ₅₀ (μM)								
	α	β1	β2	γ	δ	ε	ζ	η	
R ¹ benzyl	13.5	1.15	1.14	25	8.8	30	34	4.5	
R ² H									
R ^{1'} H									
R ^{2'} H									

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Example 15	α	β_1	β_2	γ	δ	ϵ	ζ	η
R ¹ 3- (dimethyl- amino)propyl	4.9	0.14	0.1	4	3.4	5.5	37	1.3
R ² CH ₃								
R ^{1'} dimethyl- aminomethyl								
R ^{2'} H								

Example 16	α	β_1	β_2	γ	δ	ϵ	ζ	η
R ¹ 3- (dimethyl- amino)propyl	39	0.7	0.6	9.2	8	10	40	5.6
R ² CH ₃								
R ^{1'} dimethyl- aminomethyl								
R ^{2'} CH ₃								

20 Example 17

3-(1-[3-Cyclopropylamino-1-propyl]-3-indolyl)-4-(1-methyl-3-indolyl)-1H-pyrrole-2,5-dione

To a 0°C solution of trifluoromethanesulfonic acid anhydride (188 mg, 0.67 mmol) in dry methylene chloride (15 mL) was added a solution of 3-[1-(3-hydroxy-propyl)-1H-indol-3-yl]-4-(1-methyl-1H-indol-3-yl)-pyrrole-2,5-dione (100 mg, 0.25 mmol) in THF (10 mL). After 2 hours, cyclopropylamine (200 μ L, 5 mmol) was added and stirring continued over night. The reaction mixture was quenched with water. The organic phase was separated, washed with water (3x), dried, and evaporated. The residual red oil was purified by flash chromatography on silica gel eluting with a methylene chloride/ethanol gradient (98:2 - 95:5). Evaporation of the eluting solvent gave the title compound

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(70 mg, 64% yield).

Example 17	α	β_1	β_2	γ	δ	ϵ	ζ	η
R ¹ 3- (cyclo- 5 propylamino)- propyl	2.1	0.14	0.12	4.8	2.1	4.6	26	0.27
R ² H								
R ^{1'} CH ₃								
R ^{2'} H								

10

Examples 18 to 22 are prepared in a manner analogous to the examples and description provided herein.

Example 18	α	β_1	β_2	γ	δ	ϵ	ζ	η
R ¹ R ² -CH ₂ CH ₂ CR ⁸ R ⁹ CH ₂ -	1.4	0.07	0.06	1.3	1.45	1.88	6.6	0.24
R ⁸ H								
R ⁹ CH ₂ NH ₂								
R ^{1'} CH ₃								
R ^{2'} H								

Example 19	α	β_1	β_2	γ	δ	ϵ	ζ	η
R ¹ R ² -CH ₂ CH ₂ CR ⁸ R ⁹ CH ₂ -	1.38	0.04	0.06	1.6	1.4	1.7	8.8	0.26
R ⁸ H								
R ⁹ -CH ₂ N(CH ₃) ₂								
R ^{1'} CH ₃								
R ^{2'} H								

30

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Example 20	α	β_1	β_2	γ	δ	ϵ	ζ	η
R ¹ p-methoxy-phenylmethyl	7.8	0.46	0.44	8.7	8.8	9.3	37.8	ND
R ² H								
R ^{1'} H								
R ^{2'} H								

Example 21	α	β_1	β_2	γ	δ	ϵ	ζ	η
R ¹ 3-propenyl	0.79	0.063	0.062	3.1	0.5	1.7	14	0.3
R ² H								
R ^{1'} 3-hydroxy-propyl								
R ^{2'} H								

Example 22	α	β_1	β_2	γ	δ	ϵ	ζ	η
R ¹ 3-hydroxy-propyl	0.24	0.018	0.024	0.82	0.2	0.42	9.7	0.09
R ² H								
R ^{1'} 3-hydroxy-propyl								
R ^{2'} H								

Example 23

3-[(1-[2-(β -D-2-Deoxyribopyranosyl)-hydroxyethyl]-3-indolyl)-4-(1-methyl-3-indolyl)-1H-pyrrole-2,5-dione

3-[1-(-Acetoxyethyl)-3-indolyl]-4-(1-methyl-3-indolyl-2,5-furandione (J. Med. Chem. 1992, Vol. 25, 994, 1 g, 2.3 mmol) was suspended in ethanol (100 mL). Sodium methoxide (5 mL, 5 molar in ethanol) was added. The mixture was stirred at room temperature for 4 hours, acidified with acetic acid, and concentrated. The residue was quenched with water and extracted with ethyl acetate. The organic phase was dried and concentrated to give a residue of 3-[1-(-hydroxyethyl)-3-indolyl]-4-

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(1-methyl-3-indolyl)-2,5-furandione (0.85 g). The residue was dissolved in methylene chloride (100 mL). Molecular sieves (4 g, 4Å), silver carbonate (2 g), and silver perchlorate (0.2 g) were added. To this mixture was added 5 dropwise 3,5-di-O-tolyl-2-deoxy- α -D-ribopyranosyl chloride (1 g, 2.5 mmol) (described in Chem. Ber. 1960, 2777) dissolved in methylene chloride (80 mL). The mixture was then stirred at room temperature for 24 hours, filtered, and concentrated. To this mixture was added a sodium 10 methanolate solution (1N, 20 mL). After 20 minutes, the reaction mixture was acidified (pH 4) with acetic acid and again concentrated. The residue was dissolved in ethyl acetate and washed (2x) with water, dried, and concentrated. The product (1.4 g) obtained was purified by 15 column chromatography (eluant: toluene/acetone 9:1). Evaporation of the eluant gave a residue (620 mg) that was dissolved in DMF (6 mL) and aqueous ammonia (33%, 6 mL) and heated in an autoclave (150°C) for 30 minutes. After cooling, the mixture was concentrated. The residue was 20 washed with water and dried to give the title compound (510 mg, 44% yield).

¹H-NMR (DMSO-d₆): 1.9 and 2.3 (2H, m, H-2'ab), 3.7 (2H, m, CH₂), 3.85 (3H, s, NCH₃), 3.9 (3H, s, NCH₃), 4.4 (2H, m, CH₂), 4.6-5.0 (4H, m, sugar H), 6.6-7.9 (10H, m, indole H), 10.9 (1H, s, NH). 25

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Example 23	α	β_1	β_2	γ	δ	ϵ	ζ	η
	1.2	0.082	0.076	5.7	1.2	1.5	30	0.97
R ¹								
R ²	H							
5	R ^{1'}	CH ₃						
	R ^{2'}	H						

Example 243-[1-N-(3-(cyclohexylaminecarboxy)-propyl)-indol-3-yl]-4-10 11-N-(methyl)-indol-3-yl-1H-pyrrole-2,5-dione

To a solution of 100 mg (0.25 mmol) of 3-[1-N-(3-hydroxypropyl)-indol-3-yl]-4-[1-N-(methyl)-indol-3-yl]-1H-pyrrole-2,5-dione in 5 mL of toluene was added 31 mg (0.25 mmol) cyclohexyl isocyanate and refluxed for 70 hours. The 15 mixture was evaporated, and the residue purified by flash chromatography on silica gel with methylene chloride/ethanol 95:5, yielding 60 mg of a red powder (46% of theory).

Example 24	α	β_1	β_2	γ	δ	ϵ	ζ	η
	4.8	0.14	0.13	7.1	4.8	6.8	19	1.4
R ¹								
R ²	H							
25	R ^{1'}	CH ₃						
	R ^{2'}	H						

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Examples 25 and 31 are prepared in a manner analogous to the examples and description provided herein.

5	Example 25	α	β_1	β_2	γ	δ	ϵ	ζ	η
	R ¹ methyl- carbonyloxy propyl	1	0.07	0.07	1.8	1.1	1.5	18	0.28
10	R ² H								
	R ^{1'} H								
	R ^{2'} H								

15	Example 26	α	β_1	β_2	γ	δ	ϵ	ζ	η
	R ¹ acetyloxy propyl	4.2	0.01	0.015	5.2	3	7	34	1
	R ² CH ₃								
	R ^{1'} H								
	R ^{2'} H								

20	Example 27	α	β_1	β_2	γ	δ	ϵ	ζ	η
	R ¹ 3- hydroxypropyl	3.9	0.08	0.08	2.9	2.4	7	32	2.4
	R ² CH ₃								
	R ^{1'} H								
25	R ^{2'} H								

30	Example 28	α	β_1	β_2	γ	δ	ϵ	ζ	η
	R ¹ 3-propenyl	1.98	0.18	0.17	3.3	1.2	3.2	24	1
	R ² H								
	R ^{1'} H								
	R ^{2'} H								

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Example 29	α	β_1	β_2	γ	δ	ϵ	ζ	η
5 R ¹ 3- hydroxypropyl R ² H R ^{1'} H R ^{2'} CH ₃	1.3	0.08	0.11	18	1.2	11.3	27	0.54

Example 30	α	β_1	β_2	γ	δ	ϵ	ζ	η
10 R ¹ 3- hydroxypropyl R ² CH ₃ R ^{1'} H R ^{2'} CH ₃	18.6	0.95	0.96	86	13	65	70	6.6

Example 31	α	β_1	β_2	γ	δ	ϵ	ζ	η
15 R ¹ methylamino propyl R ² H R ^{1'} H 20 R ^{2'} H	0.68	0.06	0.02	1.2	1	1	14	0.05

Example 32 + 33

3-[(1-[4-(2,5-Dideoxy-5-azido- α -D-ribofuranosyl)-
hydroxybutyl]-3-indolyl)-4-(1-methyl-3-indolyl)-
25 1H-pyrrole-2,5-dione

and

3-[(1-[4-(2,5-Dideoxy-5-azido-B-D-ribofuranosyl)-
hydroxybutyl]-3-indolyl)-4-(1-methyl-3-indolyl)-
30 1H-pyrrole-2,5-dione-pyrrole-2,5-dione

Molecular sieves (3 g, 4 Å) were added to a solution
of 3-[1-N-(4-hydroxybutyl)-3-indolyl]-4-[1-N-
(methyl)-3-indolyl]-1H-pyrrole-2,5-dione (1.3 g, 3 mmol)
and 3-O- acetyl-5-azido-2,5-dideoxy-D-ribosyl acetate (0.8
g, 3.3 mmol) in dry methylene chloride (40 mL). After 1

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hour, the mixture was cooled to -25°C and TMS-OTf (0.05 mL) was added. After 1 hour, the mixture was warmed to room temperature and quenched with triethylamine, filtered, washed with water, dried, and concentrated. The crude 5 product (1.8 g) was dissolved in dioxane (50 mL), and potassium hydroxide (5 g in 50 mL of water) was added. After 18 hours, the reaction mixture was acidified with 2N hydrochloric acid and extracted with ethyl acetate. The organic phase was washed with water, dried, and 10 concentrated. The crude product (1.2 g) obtained was dissolved in DMF (6 mL) and aqueous ammonia (33%, 25 mL, and heated in an autoclave for 2 hours (140°C). After cooling, the mixture was concentrated, dissolved in ethyl acetate, washed with water, dried, and concentrated. The 15 anomers were purified and separated on silica gel (eluant: toluene/ethanol (8:2) to give 310 mg of the α anomer and 300 mg of the β anomer.)

α anomer $^1\text{H-NMR}$ (CDCl_3): 1.6 (2H, m, CH_3), 1.9 (2H, m, CH_2), 2.1 (2H, m, H-2'ab), 3.7 (2H, m, CH_2), 3.8 (3H, s, NCH_3) 4.2 (2H, m, CH_2) 20 5.2 (1H, d, H-1'), 6.7-7.9 (10H, indole H)

β anomer $^1\text{H-NMR}$ (CDCl_3): 1.6 (2H, m, CH_2), 1.9 (2H, m, CH_2), 2.1 (m, 1H-2'a), 2.2 (m, 1H, H-2'b), 3.8 (2H, m, CH_2) 25 3.9 (3H, s, NCH_3) 4.2 (2H, m, CH_2), 5.15 (1H, d, H-1'), 6.7-7.8 (10H, indole H).

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Example 32	α	β_1	β_2	γ	δ	ϵ	ζ	η
R ¹ CH ₃	1.2	0.045	0.047	6.7	29	35	64	6.7
R ² H								
5 R ¹								
R ² H								

Example 33	α	β_1	β_2	γ	δ	ϵ	ζ	η
R ¹ CH ₃	1.9	0.11	0.05	4.4	3.2	5.5	26	2.6
R ² H								
10 R ¹								
R ² H								

15

Example 34

3-(1-[4-(2-Dideoxy- β -D-ribosyl)-hydroxybutyl]-3-indolyl)-4-(1-methyl-3-indolyl)-1H-pyrrole-2,5-dione

Molecular sieves (10 g, 4A) and silver carbonate (5 g) were added to a solution of 3-(1-[4-hydroxybutyl]-3-indolyl)-4-(1-methyl-3-indolyl)-1H-pyrrole-2,5-dione (1.2 g, 2.8 mmol) in absolute methylene chloride (100 mL). The

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mixture was stirred at room temperature for 1 hour. A solution of 3,5-di-O-tolyl- α -D-2-deoxyribopyranosyl chloride (1.32 g, 3.4 mmol) in absolute methylene chloride (30 mL) was added dropwise. After 18 hours, the reaction mixture was filtered and concentrated. The residue (3.5 g) was dissolved in dioxane (50 mL). Potassium hydroxide (5 g of KOH in 50 mL of water) was added. After 18 hours, the reaction was acidified with 2N HCl and extracted with ethyl acetate. The organic phase was washed with water, dried, and concentrated. The residue (1.1 g) was dissolved in DMF (5 mL) and aqueous ammonia (33%, 20 mL) and heated in an autoclave for 2 hours (140°C). After the usual workup, the product is purified by column chromatography (eluant: methylene chloride/ethanol 90:10). Yield of α anomer: 320 mg (30%). Yield of β anomer: 410 mg (39%).

β anomer $^1\text{H-NMR}$ (CDCl_3): 1.6 (2H, m, CH_2), 1.9 (2H, m, CH_2), 2.1 (1H m, H-2'b), 2.2 (1H, m, H-2'a), 3.8 (2H, m, CH_3), 3.85 (3H, s, NCH_3), 4.2 (2H, m, CH_3), 5.2 (1H, d, H-1'), 6.7-7.7 (10H, indole H), 8.5 (1H, s, NH).

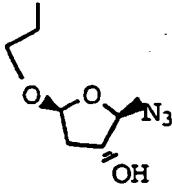
35

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Example 35

Compound was prepared in a manner analogous to the Examples 32, 33 and 34.

5	Example 35	α	β_1	β_2	γ	δ	ϵ	ζ	η
	R ¹ CH ₃	1.3	0.045	0.036	4.2	1.8	2.5	42	1.5
	R ² H								
10									
	R ¹ '								
	R ² ' H								

15

Example 36

3-[(2-(5-Acetamido-2,5-dideoxy- β -D-ribofrinosyl)-
hydroxyethyl]-3-indolyl-4-(1-methyl-3-indolyl)-1H-
pyrrole-2,5-dione

20 Compound was prepared in a manner analogous to the examples herein.

 β anomer

25 ¹H-NMR (CDCl₃): 1.8 (3H, s, NAc), 2.0 (1H, m, H-2b),
 2.2 (1H, m, H-2a), 3.7 (2H, m, CH₂),
 3.8 (3H, s, NMe), 4.2 (2H, m, CH₂),
 6.00 (1H, d, H-1), 6.7-7.7 (10H,
 indol H), 9.1 (1H, s, NH)

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Example 36	α	β_1	β_2	γ	δ	ϵ	ζ	η
R ¹ CH ₃	1.2	0.045	0.047	6.7	2.9	3.5	64	1.5
R ² H								
R ¹								
R ² H								

Example 37

3-(1-(1-Acetyl-piperidin-4-yl)-indol-3-yl)-4-(1-methyl-indol-3-yl)-pyrrole-2,5-dione

3-(1-[4-(1-t-butoxycarbonyl)-piperidinyl]-3-indolyl)-4-(1-methyl-3-indolyl)-1H-pyrrole-2,5-dione (120 mg, 0.23 mmol) was added to a solution of ethanethiol (0.27 mL) in trifluoroacetic acid (2.7 mL) precooled to 0°C with proper stirring. After 30 minutes the reaction mixture was made alkaline by careful addition of saturated aqueous sodium hydrogen carbonate and extracted with ethyl acetate. The organic phase was washed with hydrogen carbonate (2x), brine, water, and dried with sodium sulfate. After stirring overnight the solution was filtered, concentrated, and the residue chromatographed on silica gel eluting with toluene/acetone (50:50). Evaporation of the eluting solvent gave 20 mg of orange red crystals (19% yield).

M.Pt.: >293°C.

Example 37	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
5	0.3	0.009	0.02	1	0.4	0.4	20	0.1
R ¹								
R ²	H							
R ^{1'}	CH ₃							
R ^{2'}	H							
R ^{12'}	-COCH ₃							

10

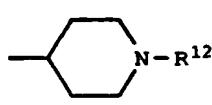
Example 383-[1-N-(1-methylencarboethoxy-piperindin-4-yl)-indol-3-yl]-4-(1-methylindol-3-yl-1H-pyrrole-2,5-dione

15 The reaction was performed under an argon atmosphere and exclusion of moisture.

To a 0°C solution of 4-(1-indolyl)-1-piperidinoacetic acid ethyl ester (520 mg, 1.8 mmol) in methylene chloride (4 mL) was added oxalyl chloride (0.165 mL, 1.9 mmol) with stirring. After 15 minutes, the 20 reaction was concentrated, and the residue suspended in dry methylene chloride (10 mL). To this suspension was added isopropyl-(1-(methyl)indole-3-yl)-acetimidate hydrochloride (480 m, 1.8 mmol), mol sieves (6 g, 0.4 Å), followed by a solution of triethylamine (1.26 mL, 9 mmol) 25 in methylene chloride (2 mL). The reaction was brought to ambient temperature for 3 hours, recooled to 0°C, and p-toluene sulfonic acid (684 mg, 3.6 mmol) was added in small portions. After 2 hours, the reaction was filtered and the filtrate was washed with NaHCO₃ (sat. aq.) (3x), 30 brine (2x) and water (1x), dried, and concentrated. The residue was chromatographed on silica gel eluting with methylene chloride/ethanol (96:4). The material obtained

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was recrystallized from ether to give the title compound (50 mg, 6% yield) as red crystals. M.Pt.: 247-252°C.

5	Example 38	IC ₅₀ (μm)							
		α	β1	β2	γ	δ	ε	ζ	η
	 R ¹	1	0.05	0.05	5	3	0.4	>100	2
	R ² H								
	R ¹ ' CH ₃								
10	R ² ' H								
	R ¹² '								
	CH ₂ CO ₂ CH ₂ CH ₃								

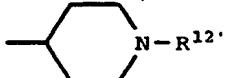
Example 39

15 3-[1-N- (1-N- (Cyclopropylmethylen)-piperidin-4-yl)-indol-3-yl]-4-(1-N-(methyl)-indol-3-yl)-1H-pyrrole-2,5-dione

1-N- [1-N- (cyclopropylmethylen)-piperidin-4-yl]-indole (460 mg, 1.81 mmol) was suspended in ether (8 mL), and the suspension was filtered. The filtrate was cooled 20 to 0°C and oxalyl chloride (0.175 mL, 2 mmol) was slowly added. After 30 minutes, the precipitate that formed was collected, washed with a small amount of ether, and resuspended in dry methylene chloride (10 mL). To this suspension was added isopropyl(1-(methyl)indole-3-yl)acetimidate hydrochloride (480 mg, 1.81 mmol), followed by the dropwise addition of triethylamine (1.26 mL, 9.05 mmol) in dry methylene chloride (3 mL). After 3 hours, p-toluene sulfonic acid (1.38 g, 7.25 mmol) was added in several portions (slightly exothermic reaction) and 30 stirring continued for an additional hour. The reaction was quenched by washing with NaHCO₃ (sat. aq.) (2x), water (1x), and back extraction of the aqueous phase with

-64-

5 methylene chloride. The combined organic solutions were dried, concentrated to a small volume, and the title compound crystallized from the solution. The collected crystals gave the title compound (200 mg, 23% of theory) as a bright orange powder (23% of theory). M.Pt.: >250°C.

		IC ₅₀ (μm)								
Example 39		α	β1	β2	γ	δ	ε	ζ	η	
		0.3	0.03	0.01	0.4	0.4	0.9	9	0.05	
10										
	R ¹									
	R ² H									
	R ^{1'} CH ₃									
	R ^{2'} H									
15	R ^{12'} cyclopropyl- methylene									

Example 40

20 3-[1-(1-Ethyl-piperidin-4-yl)-indol-3-yl]-4-(1-methyl-indol-3-yl)-pyrrole-2,5-dione

1-(1-ethyl-piperidin-4-yl)-indole (350 mg, 1.53 mmol) was dissolved in ether (6 mL), cooled to 0°C and oxalyl chloride (0.175 mL, 2 mmol) was slowly added. After 30 minutes, the precipitate which formed was collected and suspended in dry methylene chloride (10 mL). To this suspension was added isopropyl(1-methyl)indol-3-yl)acetimidate hydrochloride (410 mg, 1.53 mmol), followed by the dropwise addition of isopropyl(1-methyl)indol-3-yl)acetimidate (1.07 mL, 7.65 mmol) in dry methylene chloride (3 mL). After 3.5 hours, p-toluene sulfonic acid (1.16 g, 6.12 mmol) was added in several portions (slightly exothermic reaction) and stirring continued for an

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additional hour. Title compound was isolated as described in Example 39. Recrystallization from dioxane yielded 180 mg of bright orange crystals (26% yield). M. pt.: >250°C.

5

Example 40	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
	0.4	0.02	0.005	0.3	0.3	0.4	7	0.04
R ² H								
R ¹ ' CH ₃								
R ² ' H								
R ¹² ' CH ₂ CH ₃								

10

Example 41

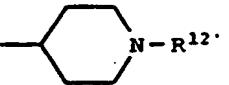
3-[1-[1-N-(3-N,N-(Dimethylamino)propyl)-piperidin-4-yl]-indol-3-yl]-4-(1-methyl-indol-3-yl)-1H-pyrrole-2,5-dione

To a stirred 0°C solution of [3-(4-indol-1-yl-piperidin-1-yl)-propyl]-dimethyl-amine (1 g, 3.25 mmol) in dry methylene chloride (10 mL) was added oxalyl chloride (0.33 mL, 4.2 mmol) and warmed up to ambient temperature for 15 minutes. The reaction was concentrated below 30°C, dissolved in dry toluene (10 mL) and treated with isopropyl(1-methyl)indol-3-yl)acetimidate hydrochloride (930 mg, 3.5 mmol). After slow addition of triethylamine (3 mL, 21 mmol) at 0°C, the mixture was stirred at ambient temperature for 1 hour and then treated with trifluoroacetic acid anhydride (3 mL). After 5 minutes the mixture was carefully quenched with saturated aqueous sodium hydrogen carbonate solution (100 mL). The organic phase was separated, washed with water, dried, and evaporated. The residue solidified on treatment with i-hexane (3x50 mL) and was filtered off. Further purification of the precipitate was accomplished by column

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chromatography on silica gel eluting with i-propanol/ ethyl acetate/ triethylamine (47:40:13). The material obtained was triturated with t-butyl methyl ether and dried. Yield: 100 mg of red powder (6% yield).

5

Example 41	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
	3	0.2	0.1	4	4	1	15	2
R ¹								
R ² H								
R ^{1'} CH ₃								
R ^{2'} H								
R ¹² CH ₂ CH ₂ CH ₂ N(CH ₃) ₂								

15

Example 42

3-[1-(1-Methyl-piperidin-4-yl)-indol-3-yl]-4-(1-methyl-indol-3-yl)-1H-pyrrole-2,5-dione

The reaction is performed under an inert gas atmosphere with rigorous exclusion of moisture.

To an ice cooled solution of 1-(1-methyl-piperidin-4-yl)-1H-indole (38 g, 0.177 mol) in dry ether (1.2 L) was added oxalyl chloride (16.7 mL, 0.195 mol) dropwise at a rate such that the internal temperature does not exceed 5°C. Stirring at 0 to 5°C is continued for 30 minutes. A yellow precipitate was isolated by suction filtration, washed with ether (800 mL) and suspended in methylene chloride (1.5 L). The solution was recooled to 0 to 5°C and treated with isopropyl(1-methyl)indol-3-yl)acetimidate hydrochloride (49.6 g, 0.186 mol) in one portion followed by dropwise addition of triethylamine (123 mL, 0.885 mol). The reaction was brought to ambient

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temperature and stirred for 3 hours. Anhydrous p-toluene sulfonic acid (152.4 g) was added in several portions with external cooling and stirring was continued for 30 minutes. The mixture was poured into saturated aqueous sodium hydrogen carbonate (2 L) and shaken. A bright orange precipitate (32.2 g) formed which was isolated by suction filtration and washed successively with water, dioxane, and ether. A second crop was isolated by evaporation of the mother liquor and trituration with dioxane (9.4 g). Total yield: 41.6 g (54% of theory). M.Pt.: 316-318°C.

		IC ₅₀ (μm)							
Example 42		α	β1	β2	γ	δ	ε	ζ	η
		0.4	0.02	0.01	0.5	0.4	0.4	4	0.05
15	R ¹								
	R ² H								
	R ¹ ' CH ₃								
	R ² ' H								
20	R ¹² ' CH ₃								

Example 43

3-[1-(1-Methyl-piperidin-4-yl)-indol-3-yl]-4-(1-methyl-indol-3-yl)-1H-pyrrole-2,5-dione hydrochloride

An ice cooled solution of 3-[1-(1-methyl-piperidin-4-yl)-1H-indol-3-yl]-4-(1-methyl-1H-indol-3-yl)-pyrrole-2,5-dione (70 g, 0.16 mol) in ethyl acetate (4 L) was saturated with gaseous hydrogen chloride for 3 hours. The precipitate formed was isolated by suction filtration, suspended in methanol (3 L) and stirred for 30 minutes. The mixture turned into a homogenous slurry, which was concentrated and treated with ether (500 mL). The title compound crystallized and was collected by suction

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filtration. The filter was vacuum dried over night (100°C/0.1 mm. Yield 70 g (92% of theory). M.Pt.: 280-282°C.

Example 44

5 3-[1-(1-carboxamidine-piperdin-4-yl)-indol-3-yl]-4-(1-
methyl-indol-3-yl)-1-pyrrole-2,5-dione

[t-Butoxycarbonylimino-(4-{3-[4-(1-methyl-1H-indol-3-yl)-2,5-dioxo-2,5-dihydro-1H-pyrrole-3-yl]-indol-1-yl}-piperidin-1-yl)-methyl]-carbamic acid t-butyl ester (110 mg, 0.17 mmol) was added to a 0°C solution of ethanethiol (0.1 mL) in trifluoroacetic acid (1 mL). After 30 minutes, the reaction mixture was brought to ambient temperature for an additional 30 minutes, quenched with saturated aqueous sodium hydrogen carbonate, and diluted with methylene chloride. The organic phase was washed with NaHCO₃ (2x), water, brine, and evaporated. The orange amorphous solid was recrystallized from hot dioxane to give the title compound (40 mg, 50% yield). M.Pt.:>210°C dec.

20

IC₅₀ (μm)

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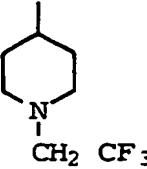
-69-

Example 45

3-(1-Methyl-indol-3-yl)-4-(1-[1-(2,2,2-trifluoro-ethyl)-piperidin-4-yl]-indol-3-yl)-1H-pyrrole-2,5-dione

To a stirred 0°C solution of 1-[1-(2,2,2-trifluoro-ethyl)-piperidin-4-yl]-indole (180 mg, 0.64 mmol) in dry ether (3 mL) was added oxalyl chloride (0.06 mL, 0.7 mmol). The reaction mixture was warmed to ambient temperature for 30 minutes. An additional amount of oxalyl chloride (0.04 mL, 0.5 mmol) was added. After 30 minutes, a yellow precipitate formed which was filtered with the exclusion of moisture and air, and washed with a small amount of ether. The collected precipitant was dissolved in dry methylene chloride (10 mL) and treated with isopropyl(1-methyl)indol-3-yl)acetimidate hydrochloride (190 mg, 0.71 mmol) followed by slow addition of triethylamine (0.44 mL, 3.2 mmol) at 0°C. After 4 hours at ambient temperature, p-toluene sulfonic acid monohydrate (0.61 g, 3.2 mmol) was added. After 30 minutes the mixture was quenched with saturated aqueous sodium hydrogen carbonate solution (40 mL). The organic phase was separated, washed with water, dried, and evaporated. The residue was recrystallized from hot dioxane and yielded 100 mg of bright orange crystals. Recrystallization of the mother liquor from THF yielded a second crop (60 mg). Yield: 160 mg of bright orange crystals (49% of theory) M.Pt.: > 250°C.

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Example 45	α	β_1	β_2	γ	δ	ϵ	ζ	η
R ¹ is CH ₃	>100	0.13	0.037	>100	69	>100	>100	>100
R ² is H								
R ^{1'}								
								
R ^{2'} is H								

Example 46

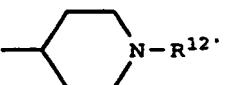
10 3-[1-[1-(2,2,3,3,4,4,4-Heptafluoro-butyl)-piperidin-4-yl]-indol-3-yl]-4-(1-methyl-indol-3-yl)-1H-pyrrole-2,5-dione

To a stirred 0°C solution of 1-(4,4,4,3,3,2,2-heptafluorobutyl)-4-(1-indolyl)-piperidine (430 mg, 1.12 mmol) in dry ether (5 mL) was added oxalyl chloride (0.11 mL, 1.23 mmol). After 1 hour at room temperature, a yellow precipitate formed. The precipitant was collected by filtration under Ar, washed with ether, suspended in dry methylene chloride (10 mL) and treated with isopropyl(1-methyl)indol-3-yl)acetimidate hydrochloride (300 mg, 1.12 mmol). To this suspension was added 20 triethylamine (0.78 mL, 5.6 mmol) in dry methylene chloride (3 mL) at 0°C. The reaction was stirred at ambient temperature for 3 hours and treated with p-toluene sulfonic acid monohydrate (slightly exothermic) (0.86 g, 4.5 mmol). After 30 minutes, the reaction was carefully 25 quenched with saturated aqueous sodium hydrogen carbonate solution (30 mL). The organic phase was separated, washed with saturated aqueous sodium hydrogen carbonate solution, water, brine, dried, and evaporated. The residue was crystallized from an ethereal solution. Yield: 260 mg of

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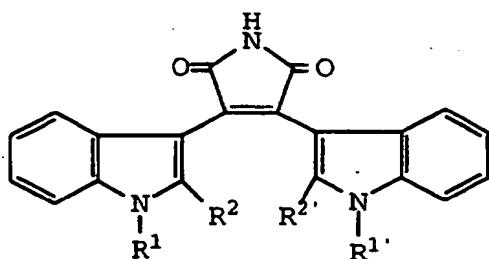
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bright orange crystals (38% of theory). M.Pt.: 231-
234°C.

5	Example 46	IC ₅₀ (μm)							
		α	β1	β2	γ	δ	ε	ζ	η
		>100	3.0	0.46	>100	>100	>100	>100	>100
	 R ¹								
	R ² H								
	R ¹ CH ₃								
10	R ² H								
	R ¹² CH ₂ CF ₂ CF ₃								

Examples 47 to 67 were prepared in a manner analogous to the examples and description provided herein.

15



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Example 47		IC_{50} (μ m)							
		α	β_1	β_2	γ	δ	ϵ	ζ	η
		1	0.1	0.05	4	2	3	52	0.5
	R ¹								
5	R ² H								
	R ^{1'} CH ₃								
	R ^{2'} H								
	R ^{12'} CH ₂ C ₆ H ₅								

Example 48		IC_{50} (μ m)							
		α	β_1	β_2	γ	δ	ϵ	ζ	η
		2	0.05	0.04	5	2	2	>100	2
	R ¹								
10	R ² H								
	R ^{1'} CH ₃								
	R ^{2'} H								
15	R ^{12'}								
	2-pyridine								

Example 49		IC_{50} (μ m)							
		α	β_1	β_2	γ	δ	ϵ	ζ	η
		0.8	0.03	0.03	2	1	0.3	8	0.4
	R ¹								
20	R ² H								
	R ^{1'} CH ₃								
	R ^{2'} H								
25	R ^{12'}								
	CH ₂ -2-pyridine								

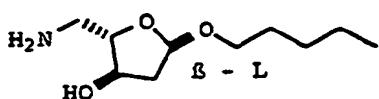
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		IC ₅₀ (μm)							
Example 50		α	β1	β2	γ	δ	ε	ζ	η
5		0.3	0.03	0.02	0.6	0.5	0.5	3	0.1
	R ¹								
	R ² H								
	R ^{1'} H								
	R ^{2'} H								
10	R ^{12'} H								
		IC ₅₀ (μm)							
Example 51		α	β1	β2	γ	δ	ε	ζ	η
15		0.2	0.02	0.01	0.5	0.4	0.05	5	0.04
	R ¹								
	R ² H								
	R ^{1'} H								
	R ^{2'} H								
20	R ^{12'} CH ₃								
		IC ₅₀ (μm)							
Example 52		α	β1	β2	γ	δ	ε	ζ	η
25		0.3	0.03	0.03	2	0.4	1	4	0.2
	R ¹								
	R ² H								
	R ^{1'} CH ₃								
	R ^{2'} H								
30	R ^{12'} H								

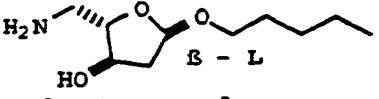
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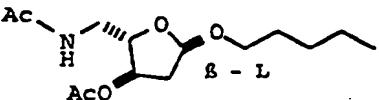
IC₅₀ (μm)

Example 53		α	β1	β2	γ	δ	ε	ζ	η
5	R ¹	3.2	0.41	0.23	4.3	3.5	6.6	51	1.7
									
	fumarate salt								
10	R ² H								
	R ^{1'} CH ₃								
	R ^{2'} H								

IC₅₀ (μm)

Example 54		α	β1	β2	γ	δ	ε	ζ	η
15	R ¹	6.7	1.1	0.34	15	7.9	4.3	37	2.5
									
	Acetate salt								
20	R ² H								
	R ^{1'} CH ₃								
	R ^{2'} H								

IC₅₀ (μm)

Example 55		α	β1	β2	γ	δ	ε	ζ	η
25	R ¹	2.3	0.26	0.05	4.2	0.95	6.6	45	1.2
									
	Acetate salt								
30	R ² H								
	R ^{1'} CH ₃								
	R ^{2'} H								

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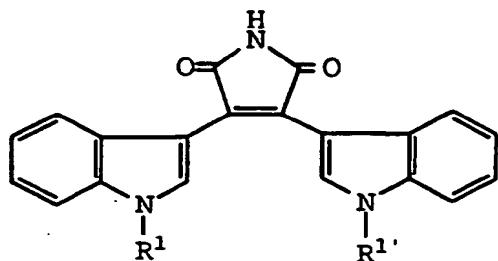
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Example 56	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
R ¹	1.6	0.069	0.039	3.2	0.93	2.4	49	1.3
5								
R ²	H							
R ^{1'}	CH ₃							
10	R ^{2'}	H						

Example 57	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
R ¹	10	1.6	0.36	NA	9.0	>100	>100	4.0
15								
R ²	H							
R ^{1'}	CH ₃							
20	R ^{2'}	H						

Example 58	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
R ¹	4.9	0.24	0.27	38	4.5	12	46	2.5
25								
R ²	H							
R ^{1'}	CH ₃							
30	R ^{2'}	H						

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		IC_{50} (μ m)							
		α	β_1	β_2	γ	δ	ϵ	ζ	η
5	Example 59 R¹ is CH ₃	4.5	0.20	0.11	9.0	2.8	31	48	1.6

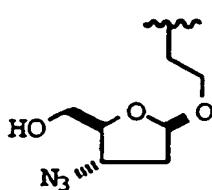
		IC_{50} (μ m)							
		α	β_1	β_2	γ	δ	ϵ	ζ	η
10	Example 60 R¹ is CH ₃	4.5	0.18	0.042	24	7.4	91	75	3.6

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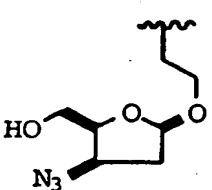
Example 61	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
R ¹ is CH ₃	3.6	0.16	0.041	4.8	3.2	20	20	0.75

5



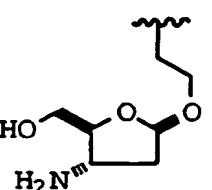
Example 62	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
R ¹ is CH ₃	4.4	0.20	0.10	5.2	3.9	42	41	2.6

10



Example 63	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
R ¹ is CH ₃	1.7	0.13	0.049	4.0	1.6	3.6	50	0.14

15



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Example 64	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
R ¹ is CH ₃	0.16	0.005	0.005	0.28	0.16	0.80	50	0.040
5 R ¹								

Example 65	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
	8.1	0.39	ND	30	8.4	ND	47	3.4
10 R ¹ Fumarate salt R ¹ ' CH ₃								

Example 66	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
	9.0	0.24	ND	30	4.4	ND	37	3.0
15 R ¹ Fumarate salt R ¹ ' CH ₃								

20

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Example 67	IC ₅₀ (μm)								
	α	β1	β2	γ	δ	ε	ζ	η	
	6.6	0.30	0.20	8.2	4.1	38	47	2.6	
5	R ¹	Fumarate salt							
	R ¹ ': CH ₃								

Example 683-(1-Methyl-indol-3-yl)-4-[1-(1-methyl-piperidin-4-ylmethylene)-indol-3-yl]-1H-pyrrole-2,5-dione

To a stirred 0°C solution of 1-(1-methyl-piperidin-4-yl)-indole (420 mg, 1.84 mmol) in dry ether (5 mL) was added oxalyl chloride (0.17 mL, 2.02 mmol). The resulting precipitant was isolated as previously described, and reacted with isopropyl-1-methylindole-3-acetamide in the same procedure as previously described to produce the title compound as a residue. The residue was chromatographed on silica gel eluting with toluene/acetone (95:5). Evaporation of the eluant and recrystallized from di-i-propyl ether gave the purified title compound. Yield: 210 mg of bright orange crystals (25% of theory). M. pt.: 228°C (dec.).

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Example 68	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
R ¹ '	1.4	0.047	0.033	2.4	1.9	4.6	9.8	0.11
								
R ¹ CH ₃								
R ¹² ' CH ₃								

Example 693-[1-(1-N-ethycarbamate-piperidin-4-yl-methylene)-indol-3-yl]-4-[1-methyindol-3-yl]-1H-pyrrole-2,5-dione

A solution containing 4-{3-[4-(1-methyl-1H-indol-3-yl)-2,5-dioxo-2,5-dihydro-1H-furan-3-yl]-indol-1-yl methyl}-piperidine-1-carboxylic acid ethyl ester (140 mg, 0.275 mmol) and 0.4 mL 33% aqueous ammonia in DMF (1.2 mL) was heated to 140°C for 2 hours in a sealed vessel, cooled down and evaporated. The residue was dissolved in methylene chloride (20 mL) and washed with water (4x25 mL), dried, and evaporated. 140 mg of bright red powder (theoretical yield). M.Pt.: 104-106°C.

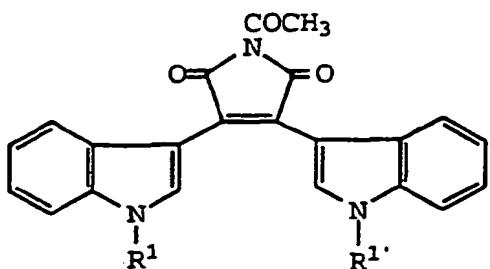
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Example 69	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
R ¹ is CH ₃	6.5	0.39	0.21	8.2	7.3	>100	>100	3.1
R ¹ '								
								
R ¹² ' C(=O)O-CH ₂ CH ₃								

The following compound was prepared in an analogous manner.

30

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		IC ₅₀ (μm)								
		Example 70	α	β1	β2	γ	δ	ε	ζ	η
5	R ¹		3.3	0.32	0.19	3.0	3.2	70	37	1.4
10										
10	R ^{1'}	CH ₃								

Example 71

15 3-[1-(Benzyl-pyrrolidin-4-yl)-indol-3-yl]-4-(1-methyl-indol-3-yl)-1H-pyrrole-2,5-dione

The title compound was prepared analogous to Example 66. Purification was accomplished by HPLC in silica gel with a methylene chloride/ethanol gradient 99:1 to 98:2. Yield: 6% of theory. MS: 500 (M⁺), 341, 303, 276, 159, 91 (100%).

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Example 71	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
R ¹ is CH ₃	3.8	0.022	0.024	3.5	4.2	9.4	>100	0.042

5

Example 723-[1-(Benzhydryl-azetidin-3-yl)-indol-3-yl]-4-(1-methyl-indol-3-yl)-1H-pyrrole-2,5-dione

10 The title compound was prepared analogous to Example 66. Purification was accomplished by HPLC on silica gel with a methylene chloride/ethanol gradient 99:1 to 98:2. Yield 3% of theory. M.Pt.: 102-105°C.

15

Example 72	IC ₅₀ (μm)							
	α	β1	β2	γ	δ	ε	ζ	η
R ¹ is CH ₃	>100	9.1	2.7	90	>100	>100	49	0.042

20

The compounds of Formula I, II, III and IV are preferably formulated prior to administration. Therefore, yet another embodiment of the present invention is a pharmaceutical formulation comprising a compound of Formula 25 II, III, and IV, and one or more pharmaceutically

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acceptable carriers, diluents or excipients.

The present pharmaceutical formulations are prepared by known procedures using well known and readily available ingredients. In making the compositions of the 5 present invention, the active ingredient will usually be mixed with a carrier, or diluted by a carrier, or enclosed within a carrier which may be in the form of a capsule, sachet, paper or other container. When the carrier serves as a diluent, it may be a solid, semisolid or liquid 10 material which acts as a vehicle, excipient or medium for the active ingredient. Thus, the compositions can be in the form of tablets, pills, powders, lozenges, sachets, cachets, elixirs, suspensions, emulsions, solutions, syrups, aerosol (as a solid or in a liquid medium), soft 15 and hard gelatin capsules, suppositories, sterile injectable solutions and sterile packaged powders.

Some examples of suitable carriers, excipients, and diluents include lactose, dextrose, sucrose, sorbitol, 20 mannitol, starches, gum acacia, calcium phosphate, alginates, tragacanth, gelatin, calcium silicate, microcrystalline cellulose, polyvinylpyrrolidone, cellulose, water syrup, methyl cellulose, methyl and propylhydroxybenzoates, talc, magnesium stearate and mineral oil. The formulations can additionally include 25 lubricating agents, wetting agents, emulsifying and suspending agents, preserving agents, sweetening agents or flavoring agents. The compositions of the invention may be formulated so as to provide quick, sustained or delayed release of the active ingredient after administration to 30 the patient. The compositions are preferably formulated in a unit dosage form, each dosage containing from about 1 to about 500 mg, more usually about 5 to about 300 mg, of the active ingredient. However, it will be understood that the therapeutic dosage administered will be determined by the

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physician in the light of the relevant circumstances including the condition to be treated, the choice of compound to be administered and the chosen route of administration, and therefore the above dosage ranges are
5 not intended to limit the scope of the invention in any way. The term "unit dosage form" refers to physically discrete units suitable as unitary dosages for human subjects and other mammals, each unit containing a predetermined quantity of active material calculated to
10 produce the desired therapeutic effect, in association with a suitable pharmaceutical carrier.

In addition to the above formulations, the compounds of the present invention may be administered topically. Topical formulations are ointments, creams, and
15 gels.

Ointments generally are prepared using either (1) an oleaginous base, i.e., one consisting of fixed oils or hydrocarbons, such as white petrolatum or mineral oil, or (2) an absorbent base, i.e., one consisting of an anhydrous substance or substances that can absorb water, for example anhydrous lanolin. Customarily, following formation of the base, whether oleaginous or absorbent, the active ingredient (compound) is added to an amount affording the desired concentration.

25 Creams are oil/water emulsions. They consist of an oil phase (internal phase), comprising typically fixed oils, hydrocarbons, and the like, such as waxes, petrolatum, mineral oil, and the like, and an aqueous phase (continuous phase), comprising water and any water-soluble substances, such as added salts. The two phases are
30 stabilized by use of an emulsifying agent, for example, a surface active agent, such as sodium lauryl sulfate; hydrophilic colloids, such as acacia colloidal clays, veegum, and the like. Upon formation of the emulsion, the

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active ingredient (compound) customarily is added to an amount to achieve the desired concentration.

Gels comprise a base selection from an oleaginous base, water, or an emulsion-suspension base. To the base 5 is added a gelling agent that forms a matrix in the base, thus increasing its viscosity. Examples of gelling agents are hydroxypropyl cellulose, acrylic acid polymers, and the like. Customarily, the active ingredient (compounds) is added to the formulation at the desired concentration at a 10 point preceding addition of the gelling agent.

The amount of compound incorporated into a topical formulation of invention is not critical; the concentration should only be a range sufficient to permit ready application of the formulation to the an affected tissue 15 area in an amount that will deliver the desired amount of compound. The customary amount of topical formulation to be applied to an affected tissue will depend upon an affected tissue size and concentration of compound in the formulation. Generally, the formulation will be applied to 20 the an affected tissue in an amount affording from about 1 to about 500 μg compound per cm^2 of an affected tissue. Preferably, the applied amount of compound will range from about 30 to about 300 $\mu\text{g}/\text{cm}^2$, more preferably, from about 25 50 to about 200 $\mu\text{g}/\text{cm}^2$, and, most preferably, from about 60 to about 100 $\mu\text{g}/\text{cm}^2$.

The following formulation examples are illustrative only and are not intended to limit the scope of the invention in any way.

30

Formulation 1

Hard gelatin capsules are prepared using the following ingredients:

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	Quantity (mg/capsule)
Active ingredient	250
starch, dried	200
5 magnesium stearate	<u>10</u>
Total	460 mg

The above ingredients are mixed and filled into hard gelatin capsules in 460 mg quantities.

10

Formulation 2

A tablet is prepared using the ingredients below:

	Quantity (mg/capsule)
15 Active ingredient	250
cellulose, microcrystalline	400
silicon dioxide, fumed	10
stearic acid	<u>5</u>
Total	665 mg

20

The components are blended and compressed to form tablets each weighing 665 mg.

Formulation 3

25 An aerosol solution is prepared containing the following components:

	Quantity (mg/capsule)
Active ingredient	0.25
30 ethanol	29.75
Propellant 22 (chlorodifluoromethane)	<u>70.00</u>
Total	100.00

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The active compound is mixed with ethanol. The mixture is added to a portion of the Propellant 22, cooled to -30°C and transferred to a filling device. The required amount is then fed to a stainless steel container and diluted with 5 the remainder of the propellant. The valve units are then fitted to the container.

Formulation 4

Tablets each containing 60 mg of active ingredient 10 are made as follows:

	Quantity (mg/capsule)
Active ingredient	60 mg
starch	45 mg
15 microcrystalline cellulose	35 mg
polyvinylpyrrolidone (as 10% solution in water)	4 mg
sodium carboxymethyl starch	4.5 mg
magnesium stearate	0.5 mg
20 talc	1 mg
Total	150 mg

The active ingredient, starch and cellulose are passed through a No. 45 mesh U.S. sieve and mixed thoroughly. The 25 solution of polyvinylpyrrolidone is mixed with the resultant powders which are then passed through a No. 14 mesh U.S. sieve. The granules so produced are dried at 50°C and passed through a No. 18 mesh U.S. sieve. The sodium carboxymethyl starch, magnesium stearate and talc, 30 previously passed through a No. 60 mesh U.S. sieve, are then added to the granules which, after mixing, are compressed on a tablet machine to yield tablets each weighing 150 mg.

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Formulation 5

Capsules each containing 80 mg of medicament are made as follows:

5

	Quantity (mg/capsule)
Active ingredient	80 mg
starch	59 mg
microcrystalline cellulose	59 mg
10 magnesium stearate	<u>2 mg</u>
Total	200 mg

The active ingredient, cellulose, starch and magnesium stearate are blended, passed through a No. 45 mesh U.S. 15 sieve, and filled into hard gelatin capsules in 200 mg quantities.

Formulation 6

Suppositories each containing 225 mg of active 20 ingredient may be made as follows:

	Quantity (mg/capsule)
Active ingredient	225 mg
saturated fatty acid glycerides	2,000 mg
25 Total	2,225 mg

The active ingredient is passed through a No. 60 mesh U.S. sieve and suspended in the saturated fatty acid glycerides previously melted using the minimum heat necessary. The 30 mixture is then poured into a suppository mold of nominal 2 g capacity and allowed to cool.

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Formulation 7

Suspensions each containing 50 mg of medicament per 5 mL dose are made as follows:

	Quantity (mg/capsule)
5	
Active ingredient	50 mg
sodium carboxymethyl cellulose	50 mg
syrup	1.25 mL
benzoic acid solution	0.10 mL
10 flavor	q.v.
color	q.v.
purified water to total	5 mL

15 The medicament is passed through a No. 45 mesh U.S. sieve and mixed with the sodium carboxymethyl cellulose and syrup to form a smooth paste. The benzoic acid solution, flavor and color are diluted with some of the water and added, with stirring. Sufficient water is then added to produce the required volume.

20

Formulation 8

An intravenous formulation may be prepared as follows:

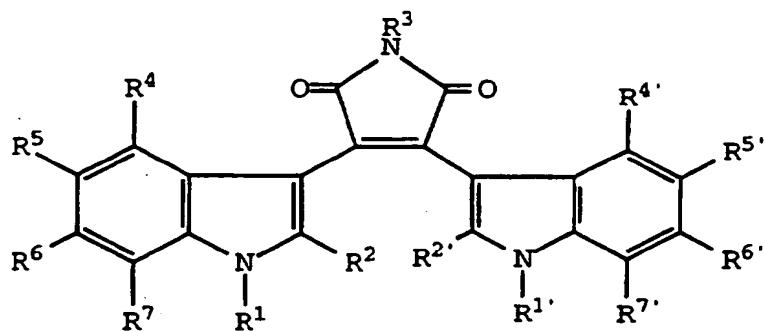
	Quantity (mg/capsule)
25	
Active ingredient	250 mg
isotonic saline	1000 mg

30 The solution of the above ingredients is administered intravenously at a rate of 1 mL per minute to a subject in need of treatment.

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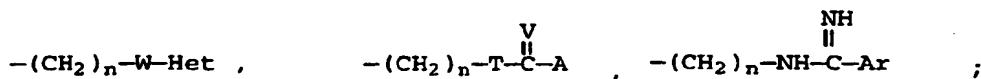
Claims

1. A compound of the Formula:



5 wherein:

R¹ and R^{1'} are independently hydrogen, alkyl, haloalkyl, alkenyl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, monoalkylaminoalkyl, dialkylaminoalkyl, acylaminoalkyl, acyloxyalkyl, cyanoalkyl, amidinoalkyl, 10 carboxyalkyl, alkoxy carbonylalkyl, aminocarbonylalkyl, or a group of the formula:



(a)

(b)

(c)

Het signifies a heterocyclyl group;

15 W signifies NH, S or a bond;

T signifies NH or S;

V signifies O, S, NH, or NCN;

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A signifies alkylthio, amino, monoalkylamino or dialkylamino;

Ar signifies aryl;

R² and R^{2'} are independently hydrogen, alkyl,

5 alkoxyalkyl, hydroxyalkyl, C₁-C₃ alkylthio, S(0)C₁-C₃ alkyl, CF₃; or R¹ and R² can combine to form -(CH₂)_r-X-CH₂-;

R³ is hydrogen or CH₃CO;

R⁴, R^{4'}, R⁵, R^{5'}, R⁶, R^{6'}, R⁷ and R^{7'} are independently hydrogen, halogen, alkyl, hydroxy, alkoxy, -COO(C₁-C₃ alkyl),

10 CF₃, nitro, amino, acetylarnino, monoalkylamino, dialkylamino, alkylthio, C₁-C₃ alkylthio, or S(0)C₁-C₃ alkyl;

X is CHR⁸ or NR⁸;

R⁸ is (CH₂)_sR⁹;

R⁹ is hydrogen, hydroxy, alkoxy, amino,

15 monoalkylamino, dialkylamino, trialkylamino, azido, acylarnino, alkoxy carbonyl, cyano, amidino, or aminocarbonyl;

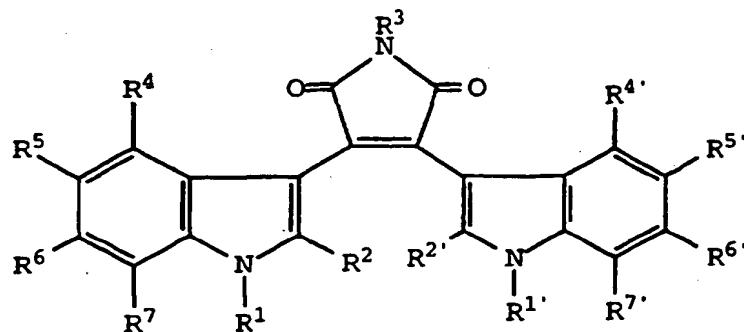
n is 1, 2, 3, 4, 5 or 6;

r is 1, 2, or 3; and

s is 0, 1, 2 or 3;

20 for use in treating diabetes mellitus.

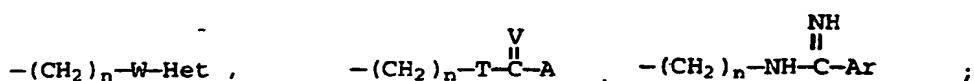
2. A compound of the Formula:



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wherein:

R¹ and R^{1'} are independently hydrogen, alkyl, haloalkyl, alkenyl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, monoalkylaminoalkyl, dialkylaminoalkyl, 5 acylaminoalkyl, acyloxyalkyl, cyanoalkyl, amidinoalkyl, carboxyalkyl, alkoxy carbonylalkyl, aminocarbonylalkyl, or a group of the formula:



(a)

(b)

(c)

10 Het signifies a heterocyclyl group;
 W signifies NH, S or a bond;
 T signifies NH or S;
 V signifies O, S, NH, or NCN;
 A signifies alkylthio, amino, monoalkylamino or
 15 dialkylamino;
 Ar signifies aryl;
 R² and R^{2'} are independently hydrogen, alkyl, alkoxyalkyl, hydroxyalkyl, C₁-C₃ alkylthio, S(0)C₁-C₃ alkyl, CF₃; or R¹ and R² can combine to form -(CH₂)_r-X-CH₂-;
 20 R³ is hydrogen or CH₃CO;
 R⁴, R^{4'}, R⁵, R^{5'}, R⁶, R^{6'}, R⁷ and R^{7'} are independently hydrogen, halogen, alkyl, hydroxy, alkoxy, -COO(C₁-C₃ alkyl), CF₃, nitro, amino, acetyl amino, monoalkylamino, dialkylamino, alkylthio, C₁-C₃ alkylthio, or S(0)C₁-C₃ alkyl;
 25 X is CHR⁸ or NR⁸;
 R⁸ is (CH₂)_sR⁹;
 R⁹ is hydrogen, hydroxy, alkoxy, amino, monoalkylamino, dialkylamino, trialkylamino, azido, acylamino, alkoxy carbonyl, cyano, amidino, or aminocarbonyl;

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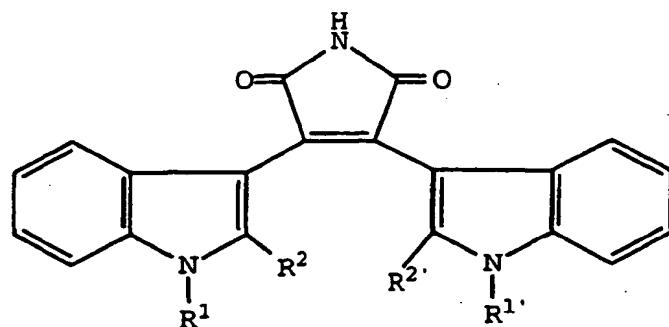
n is 1, 2, 3, 4, 5 or 6;

r is 1, 2, or 3; and

s is 0, 1, 2 or 3;

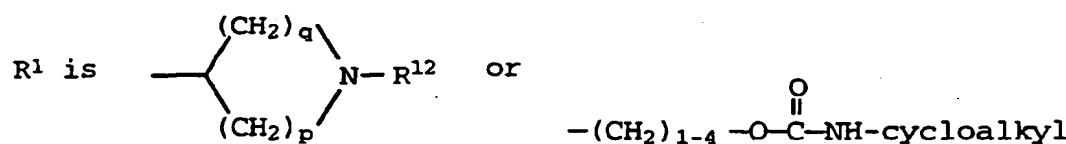
for use in selectively inhibiting protein kinase C beta-1 and
5 beta-2 isozymes.

3. A compound of the formula



10

wherein:



R¹' is hydrogen, alkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, monoalkylaminoalkyl, dialkylaminoalkyl, acylaminoalkyl;

15 R² and R²' are independently hydrogen, alkyl, alkoxyalkyl, hydroxyalkyl, CF₃; or R¹ and R² can combine to form -(CH₂)_rX(CH₂)_s-;

X is CR⁸R⁹;

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R⁸ is (CH₂)_sR¹⁰;

R⁹ is (CH₂)_sR¹¹;

R¹⁰ and R¹¹ are independently hydroxy, alkoxy, amino, monoalkylamino, dialkylamino, trialkylamino, azido,

5 acylamino, alkoxycarbonyl, cyano, amidino, or aminocarbonyl;

R¹² is alkyl, aryl, benzyl, carboxy, alkoxycarbonyl, or heterocyclyl;

p and q are 2, p is 1 and q is 3 or p is 1 and q is 2;

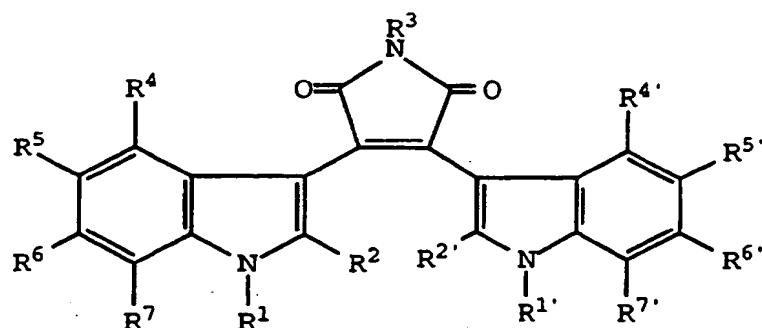
10 r is 1, 2 or 3; and

s is 0, 1, 2 or 3;

or a pharmaceutically accepted salt or solvate thereof.

4. A compound of the formula:

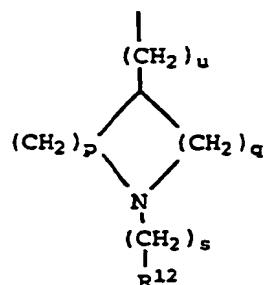
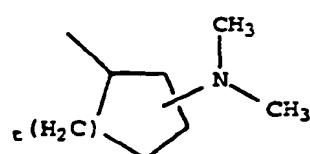
15



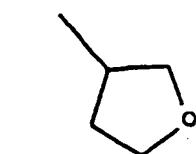
wherein:

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R¹ is (d)

(e)



or (f);

R¹ is hydrogen, C₁-C₄ alkyl, aminoalkyl, monoalkylaminoalkyl, or dialkylaminoalkyl;

5 R² and R²' are independently hydrogen, alkyl, alkoxyalkyl, hydroxyalkyl, C₁-C₃ alkylthio, S(0)C₁-C₃ alkyl, CF₃;

R³ is hydrogen or CH₃CO-;

10 R⁴, R⁴', R⁵, R⁵', R⁶, R⁶', R⁷ and R⁷' are independently hydrogen, halogen, alkyl, hydroxy, alkoxy, -COO(C₁-C₃ alkyl), CF₃, nitro, amino, acetyl amino, monoalkylamino, dialkylamino, alkylthio, C₁-C₃ alkylthio, or S(0)C₁-C₃ alkyl;

15 R¹² is hydrogen, alkyl, haloalkyl, cycloalkyl, acetyl, aryl, -CH(aryl)₂, amino, monoalkylamino, dialkylamino, guanidino, -C(=N(alkoxycarbonyl))NH(alkoxycarbonyl), amidino, hydroxy, carboxy, alkoxy carbonyl or heterocyclyl;

p and q are independently 1, 2, 3, or 4;

s is 0, 1, 2 or 3;

t is 1 or 2;

20 u is 0 or 1; or

pharmaceutically acceptable salts or solvates thereof.

5. 3-[1-(1-Methyl-piperidin-4-yl)-1H-indol-

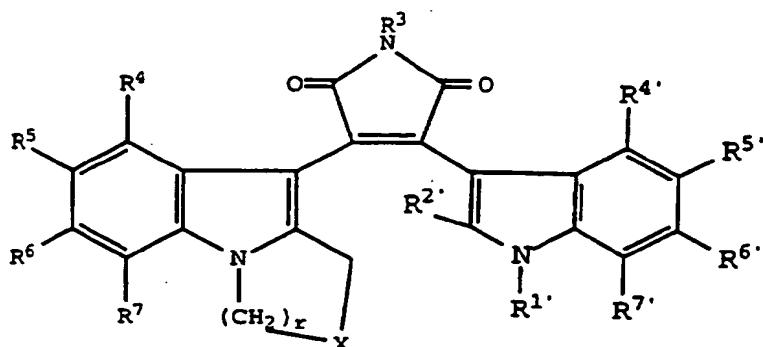
SUBSTITUTE SHEET (RULE 26)

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3-yl]-4-(1-methyl-1H-indol-3-yl)-pyrrole-2,5-dione or pharmaceutically acceptable salts or solvates thereof.

6. A compound of the formula:

5



wherein:

R¹ is hydrogen, C₁-C₄ alkyl, aminoalkyl, monoalkylaminoalkyl, or dialkylaminoalkyl;

10 R² is hydrogen, alkyl, alkoxyalkyl, hydroxyalkyl, C₁-C₃ alkylthio, S(0)C₁-C₃ alkyl, CF₃;

R³ is hydrogen or CH₃CO-;

R⁴, R^{4'}, R⁵, R^{5'}, R⁶, R^{6'}, R⁷ and R^{7'} are independently hydrogen, halogen, alkyl, hydroxy, alkoxy, -COO(C₁-C₃ alkyl), 15 CF₃, nitro, amino, acetylarnino, monoalkylarnino, dialkylarnino, alkylthio, C₁-C₃ alkylthio, or S(0)C₁-C₃ alkyl;

X is CR⁸R⁹;

R⁸ is (CH₂)_sR¹⁰;

R⁹ is (CH₂)_sR¹¹;

20 R¹⁰ and R¹¹ are independently hydroxy, alkoxy, carboxy, acyloxy, amino, monoalkylarnino, dialkylarnino, trialkylarnino, azido, acylarnino, alkoxy carbonyl, cyano, amidino, or aminocarbonyl;

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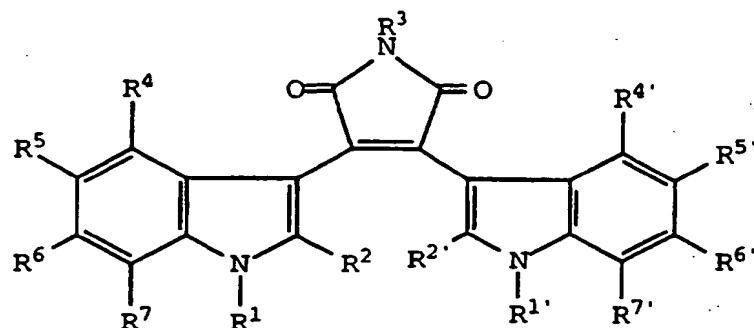
r is 1, 2, or 3;

s is 0, 1, 2 or 3; or

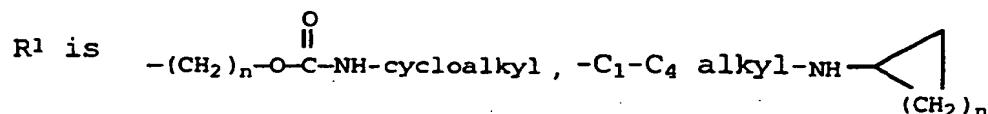
pharmaceutically acceptable salts or solvates thereof.

5

7. A compound of the formula:



wherein:



or alkylglycose residue;

10 R^{1'} is hydrogen, C₁-C₄ alkyl, cyclopropylmethyl, aminoalkyl, monoalkylaminoalkyl, or dialkylaminoalkyl; R² and R^{2'} are independently hydrogen, alkyl, alkoxyalkyl, hydroxyalkyl, C₁-C₃ alkylthio, S(0)C₁-C₃ alkyl, CF₃;

15 R³ is hydrogen or CH₃CO-;

R⁴, R^{4'}, R⁵, R^{5'}, R⁶, R^{6'}, R⁷ and R^{7'} are independently hydrogen, halogen, alkyl, hydroxy, alkoxy, -COO(C₁-C₃ alkyl), CF₃, nitro, amino, acetyl amino, monoalkylamino, dialkylamino, alkylthio, C₁-C₃ alkylthio, or S(0)C₁-C₃ alkyl;

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n is 1, 2, 3, 4, 5 or 6; or
pharmaceutically acceptable salts or solvates thereof.

8. A compound as claimed in any of claims 3 to 7 for
5 use as a pharmaceutical.

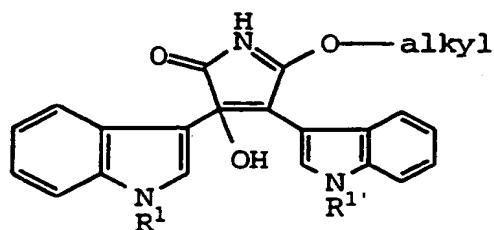
9. A compound as claimed in any of claims 3 to 7 for
use in treating diabetes mellitus.

10 10. A compound as claimed in any of claims 3 to 7
for use in selectively inhibiting protein kinase C beta-1 and
beta-2 isozymes.

15 11. A pharmaceutical formulation comprising as an
active ingredient a compound as claimed in any one of claims
3 to 7, associated with one or more pharmaceutically
acceptable carriers, excipients, or diluents thereof.

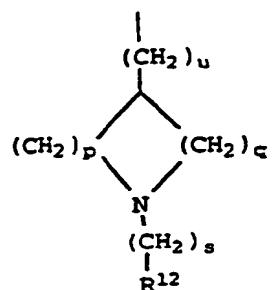
20 12. A process for preparing a compound as claimed in
any one of claims 3 to 5, which comprises:

Hydrolyzing and dehydrating a hydroxy-pyrrolinone of
the Formula:

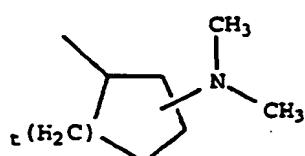


SUBSTITUTE SHEET (RULE 26)

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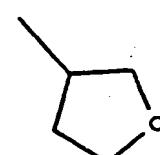


(d)



(e)

or

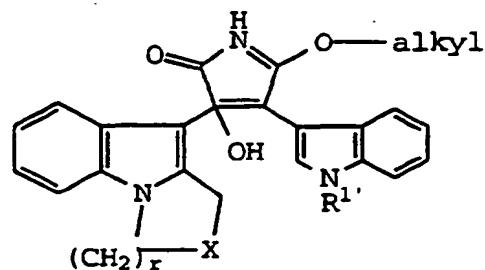


wherein R^1 is

R^{12} is hydrogen, alkyl, haloalkyl, cycloalkyl, acetyl, aryl, $-CH(aryl)_2$, amino, monoalkylamino, dialkylamino, guanidino, $-C(=N(alkoxycarbonyl))NH(alkoxycarbonyl)$, amidino, hydroxy, carboxy, alkoxycarbonyl or heterocyclyl; p and q are independently 1, 2, 3, or 4; s is 0, 1, 2 or 3; t is 1 or 2; u is 0 or 1.

10 13. A process for preparing a compound as claimed in
claim 6, which comprises:

Hydrolyzing and dehydrating a hydroxy-pyrrolinone of the Formula:



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wherein X is CR⁸R⁹; R⁸ is (CH₂)_sR¹⁰;
R⁹ is (CH₂)_sR¹¹; R¹⁰ and R¹¹ are independently hydroxy,
alkoxy, carboxy, acyloxy, amino, monoalkylamino,
dialkylamino, trialkylamino, azido, acylamino,
5 alkoxycarbonyl, cyano, amidino, or aminocarbonyl; r is 1, 2,
or 3; and s is 0, 1, 2 or 3.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/14313

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :Please See Extra Sheet.

US CL :Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS, DIALOG, CAS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4,785,085 (KANEKO ET AL) 15 NOVEMBER 1988, see entire document.	1-11
A	US, A, 4,808,613 (KANEKO ET AL) 28 FEBRUARY 1989, see entire document.	1-11
Y	US, A, 5,057,614 (DAVIS ET AL) 15 OCTOBER 1991, see entire document.	1, 2, 8-11
Y, P	US, A, 5,292,747 (DAVIS ET AL) 08 MAY 1994, see entire document.	1, 6, 8-11
Y, E	US, A, 5,380,746 (BARTH ET AL) 10 JANUARY 1995, see entire document.	1-4, 7, 8-11
Y, P	EP,A, 0,624,586 (HASSIS ET AL.) 17 NOVEMBER 1994, see entire document.	1, 6, 8-11

 Further documents are listed in the continuation of Box C. See patent family annex.

Special categories of cited documents:			
A	document defining the general state of the art which is not considered to be of particular relevance	*T*	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
E	earlier document published on or after the international filing date	*X*	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
L	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Y*	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
O	document referring to an oral disclosure, use, exhibition or other means	*&*	document member of the same patent family
P	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

23 FEBRUARY 1995

Date of mailing of the international search report

13 MAR 1995

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer

CELIA CHANG

Telephone No. (703) 308-4702

Form PCT/ISA/210 (second sheet)(July 1992)*

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US94/14313

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE, A, 3,914,764 (BARTH ET AL) 11 AUGUST 1990, see entire document.	1-4, 7-11
Y	EP, A, 0,540,956 (HILL ET AL) 05 DECEMBER 1993, see entire document	12-13
Y	JOURNAL OF MEDICINAL CHEMISTRY, Volume 36, No. 1, issued 1993, Rino A. Bit, et al., "Inhibitors of protein kinase C. 3. Potent and highly selective bisindolylmaleimides by conformational restriction", pages 21-29, see pages 21-22.	1, 2, 6, 8-11
Y	JOURNAL OF MEDICINAL CHEMISTRY, Volume 35, No. 6, issued 1992, Peter D Davis et al., "Inhibitors of protein kinase C. 2. Substituted bisindolylmaleimides with improved potency and selectivity", pages 994-1001, see pages 995-996.	1, 2, 8-11
Y	JOURNAL OF MEDICINAL CHEMISTRY, Volume 35, No. 1, 1992, Peter D. Davis et al., "Inhibitors of protein kinase C. 1. 2,3-bisarylmaleimides", pages 177-184, see entire document.	1, 2, 8-11
Y	JOURNAL OF BIOLOGICAL CHEMISTRY, Volume 268, No. 13, issued 05 MAY 1993, G. Martiny-Baron et al., "Selective inhibition of protein kinase C isozymes by the indolocarbazole Go 6976", pages 9194-9197, see page 9195	1, 2, 8-11
Y	BIOCHEMICAL JOURNAL, Volume 294, issued 1993, S. E. Wilkinson et al., "Isoenzyme specificity of bisindolylmaleimides, selective inhibitors of protein kinase C", pages 335-337, see page 336	1, 2, 6, 8-11
Y	DRUGS EXPERIMENT AND CLINICAL RESEARCH, Volume 17, issued 1991, Nixon J.S. Bishop et all., "Novel, potent and selective inhibitors of protein kinase C show oral antiinflammatory activity", pages 389-393, see entire document.	1, 2, 6, 8-11
Y	TETRAHEDRON LETTERS, Volume 31, No. 36, issued 1990, Peter D. Davis et al., "A mild conversion of maleic anhydrides into maleimides", pages 5201-5204, see entire document.	1, 2, 8-11
Y	AGENTS ACTIONS, Volume 37, issued 1992, M. J. Mulqueen et al., "Oral anti-inflammatory activity of a potent selective protein kinase C inhibitor", pages 85-89, see entire document.	1, 6, 8-11

Form PCT/ISA/210 (continuation of second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US94/14313

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

The additional search fees were accompanied by the applicant's protest.

No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/14313

A. CLASSIFICATION OF SUBJECT MATTER:

IPC (6):

A61K 31/40, 31/44, 31/55, 31/70, 31/445;
C07D 209/00, 221/00, 223/00, 403/04, 405/04, 405/14, 471/04, 487/04.

A. CLASSIFICATION OF SUBJECT MATTER:

US CL :

514/43, 214, 294, 323, 414, 422, 429;
536/22, 23, 26, 28.6;
540/479, 480, 586, 602;
546/94, 201;
548/430, 455, 466, 468

B. FIELDS SEARCHED

Minimum documentation searched

Classification System: U.S.

514/43, 214, 294, 323, 414, 422, 429;
536/22, 23, 26, 28.6;
540/479, 480, 586, 602;
546/94, 201;
548/430, 455, 466, 468

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claims 4-5, 12 and claims 1-3, 8-11 in part, drawn to compounds containing four heterocyclic ring systems, their compositions, method of making and using.

Group II, claims 6, 13, and claims 1-3, 8-11 in part, drawn to compounds containing three heterocyclic ring systems, their compositions, method of making and using.

Group III, claims 7 and 8-11 in part, drawn to glycoses etc. containing compounds, their compositions, and method of using.

The inventions listed as Groups I-III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Compounds of groups I-III lack substantial similarity in structural feature as to form a single inventive concept because compounds of group I contains four heterocyclic ring systems, two bicyclic, two monocyclic; compounds of group II contains three heterocyclic ring systems, one tricyclic, one bicyclic, one monocyclic; compounds of group III contains cycloalkylamino moiety or glycoses substituted heterocyclic ring systems. Therefore, special technical feature linking the three groups of compounds as a single inventive concept is lacking.